EVALUATION OF EMISSION PROJECTION TOOLS AND EMISSION GROWTH SURROGATE DATA

Prepared for:

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ACRONYMS AND ABBREVIATIONS

AFS	AIRS Facility Subsystem
AIRS	Aerometric Information Retrieval System
AMS	AIRS Area and Mobile Subsystem
ARB	Air Resources Board
AWMA	Air and Waste Management Association
BEA	Bureau of Economic Analysis
BEIS	Biogenic Emission Inventory System
Btu	British thermal units
C_2F_6	perfluoroethane
CE	control efficiency
CEFS	California Emission Forecasting System
CEH	Chemical Economics Handbook
CEIDARS	California Emission Inventory Development and Reporting System
CF_4	tetrafluoromethane
CH_4	methane
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CSUF	California State University at Fullerton
CTG	control technique guidelines
DOE	Department of Energy
EDFS	Economic Demographic Forecasting System
EFM	Emission Forecasting Model
EGAS	Economic Growth Analysis System
EIC	Emission Inventory Code
EIIP	Emission Inventory Improvement Program
EMS	Emissions Modeling System
EPS	Emissions Preprocessor System
FIPS	Federal Information Processing Standard
GIS	Geographic Information System
g/mi	grams per mile
HFC	hydrofluorocarbon
HFCM	Highway Fuel Consumption Model
HPC	high-performance-computing
HPMS	Highway Performance Monitoring System
IDA	Inventory Data Analyzer
kWh	kilowatt hour
LADCO	Lake Michigan Air Directors Consortium
LPG	liquefied petroleum gas
MACT	maximum achievable control technology
MCNC	Microelectronics Center of North Carolina
MPS	Multiple Projections System
MSA	Metropolitan Statistical Area
MW	megawatt

ACRONYMS AND ABBREVIATIONS (continued)

N_2O	nitrous oxides
NAICS	North American Industrial Classification System
NET	National Emissions Trends
NEVES	Nonroad Engine and Vehicle Emission Study
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
OAQPS	Office of Air Quality Planning and Standards
PC	personal computer
PM	particulate matter
PM_{10}	primary particulate matter with an aerodynamic diameter less than or equal to 10 micrometers
$PM_{2.5}$	primary particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers
PROMULA	PROcessor of MUltiple LAnguages
PSR	Power Systems Research
QA	quality assurance
QC	quality control
RACT	reasonably available control technology
RDIS	Residual Discharge Information System
RE	rule effectiveness
REMI	Regional Economic Models, Inc.
RFP	reasonable further progress
ROG	reactive organic gases
RP	rule penetration
RTS	Rule Tracking Subsystem
SCC	Source Classification Code
SF_6	sulfur hexafluoride
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	sulfur dioxide
SO_x	sulfur oxides
SSI	Systematic Solutions, Inc.
TOG	total organic gases
TSP	total suspended particulates
UAM	Urban Airshed Model
VOC	volatile organic compound
WEFA	Wharton Econometrics Forecasting Associates
WP	World Petrochemicals

SECTION I
INTRODUCTION

The purpose of this document is to: (1) evaluate emission projection tools; and (2) identify emission growth surrogate data that can be used in developing emission forecasts. Emission projection tools evaluated include models developed for State Implementation Planning (SIP) development and other air planning purposes (e.g., the Multiple Projections System [MPS]) as well as emissions models used to create inputs to air quality modeling tools (e.g., the Emissions Preprocessor System [EPS] 2.5). Included in the investigation of emission growth surrogate data is forecast data developed by economic forecasting firms, such as DRI, and market research firms, such as the Freedonia Group, Inc.

This document is organized as follows. Section II describes and evaluates emission projection tools. This section includes a discussion of the projections tool evaluation criteria identified by the Emission Inventory Improvement Program (EIIP) Projections Committee and an analysis of eight emission projection tools based on these criteria. Section III discusses surrogate emissions growth data that can be used as inputs to emission projections models. This section describes both Economic Growth Analysis System (EGAS) Version 4.0 and alternative sources of emissions growth surrogate data. A comparison of EGAS 4.0-based growth factors with Freedonia Group, Inc.-based growth factors is also presented. Section IV provides conclusions based on the Section II projection tool evaluations and the discussion of available emission growth surrogate data in Section III. Section IV includes discussions of potential improvements to the emission projection tools and to future versions of EGAS. Appendix A presents detailed information on some of the alternative emission growth surrogate data highlighted in Section III.

SECTION II
EVALUATION OF EMISSION PROJECTION TOOLS

A. INTRODUCTION

The purpose of this section is to describe and evaluate the eight emission projections tools identified by the EIIP Projections Committee (hereafter referred to as the Committee). The tools reviewed in this chapter are:

- the California Emission Forecasting System (CEFS);
- Canada's Emission Forecasting Model (EFM);
- ENERGY 2020;
- the Multiple Projection System (MPS);
- the NONROAD model;
- the Emissions Preprocessor System (EPS) 2.5;
- the Emissions Modeling System (EMS)-95; and
- the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System.

The final three tools are all applied as part of air quality models and are described in a separate subsection.

The remainder of this section is organized as follows. The following subsection describes the seven criteria used to evaluate each emission projections tool. The Committee approved the use of these criteria in the projections tool evaluation. This is followed by assessments of each projections tool based on these criteria. This section concludes with a summary of the emission projection tools, including two tables: the first highlighting the inputs and outputs associated with each tool, and the second displaying the availability and coverage evaluations for each tool.

B. EVALUATION CRITERIA

To provide a consistent method for evaluating each of the eight emission projection tools, the Committee identified a set of seven criteria. These criteria, which are described in this section, were used to assess the strengths and weaknesses of each of the projection tools, and to identify whether existing tools are sufficient for performing emission projections, or if significant modifications to these tools, or possibly the development of new tools, is warranted.

1. Availability

The first criterion of importance is to identify how available each model is to the user community. Questions to be answered for this criterion include: is the model or its source code proprietary? Are there licensing/cost issues associated with use of the model? On what platform

does the model run? To the extent possible, the following will be identified for each of the eight emission projection tools:

Proprietary source code	*Yes/No*
Licensing issues	*Specify*
Cost	*Amount*
Platform:	
Intel-based/windows	*yes/no*
Intel-based/NT	*yes/no*
Intel-based/Linux	*yes/no*
UNIX	*Version(s)*
Apple	*Version(s)*

2. Coverage

The second criterion pertains to the emissions coverage of each model. The questions that are answered in this section include: what is the scope of the model with respect to: emission source categories, pollutants, geography, and time horizon (e.g., is the model limited to only certain areas or source categories)? This criterion describes the following specific model coverage information:

Categories	*Source Classification Codes (SCCs)*	
	Standard Industrial Classification (SIC) codes	
	North American Industrial Classification System (NAICS)	
Pollutants	*Criteria pollutants (which ones)*	
	Greenhouse gases (which ones)	
	Toxics (which ones)	
Geography	*Nation-wide*	*(yes/no)*
	County level	*(yes/no)*
	Metropolitan Statistical Area (MSA)	*(yes/no)*
	User-specified grid	*(yes/no)*
	Other(s)	*Specify*
Time Periods	*Annual, seasonal, monthly, daily, hourly*	
	Historical period	*Back to ?*
	Forecast period	*To ?*

3. Model Detail

The third criterion evaluates how detailed the model is in terms of its inputs and outputs. In particular, this criterion describes the level of geographic and emission source detail at which each model is defined.

4. Comprehensiveness

This criterion concerns the extent to which the models take each of the factors that affects future emissions into account (e.g., equipment turnover, technology/process changes, emission regulations).

5. Currency/Ease of Updates

The purpose of this fifth criterion is to identify answers to the following questions:

- How recently was each model's inputs last updated;
- How often/how easy is it to update these inputs; and
- What is the source of these input data and what is the cost for these input data?

6. Flexibility

The "flexibility" criterion identifies the ability of the model user to select model assumptions, input their own data (e.g., can the user add a specific control to a specific facility), and run individual portions of the model as stand-alone applications (i.e., the level of modularity).

7. Documentation

The final criterion evaluates how well the model algorithms, input data, and output data are documented.

C. ASSESSMENT OF EMISSION PROJECTION TOOLS

This subsection presents the assessment of each of the eight emission projection tools. The first five tools are used to develop projected emission inventories, while the final three tools are components of air quality models such as EPS 2.5, which is part of the Urban Airshed Model (UAM). To the extent possible given the information available, each of the following projection tools are examined using the seven evaluation criteria described in the previous section.

1. Emission Projection Tools

a. California Emission Forecasting System (CEFS)

The California Air Resources Board (ARB) and California State University at Fullerton (CSUF) have been creating an updated emission forecasting tool for California. The tool incorporates new forecasting logic, new methods for estimating seasonal emissions for planning purposes, day-specific emissions for air quality models, and for spatial analysis of emissions. The CEFS requires the integration of various data models, such as the California Emission Inventory Development and Reporting System (CEIDARS) base year inventory, the rule tracking subsystem, socioeconomic activity, temporal activity, and Geographic Information System (GIS) data. ARB staff is responsible for overall project management and conceptual design, while

CSUF staff are responsible for software construction. Because this tool has not been fully documented and future modifications are planned, it was not possible to evaluate the CEFS against all of the Committee's projections tool criteria. A background document on the CEFS is available from the following ARB web-site: http://www.arb.ca.gov/emisinv/pubs/cefs_mj.pdf.

The CEFS includes two separate forecast algorithms: 1) TREND forecast module, which aggregates emissions by source categories (SCC/SIC; emission inventory code [EIC]) for each region (defined by District/Air Basin/County); and 2) GIS forecast module, which performs emission projections at the facility/device/process level for developing gridded inventory inputs for photochemical modeling.

Availability - The CEFS has been specifically designed for use by the State of California and California air quality management district personnel. The CEFS is resident at the Teale Data Center in Sacramento, California, on a SUN SPARCserver 1000, and runs under Sun OS 5.5.

Coverage - The CEFS provides good coverage of source categories, pollutants, California geography and time periods. CEFS contains all source categories, although particular emphasis is placed on stationary sources. It is set-up to use the SIC system, and not the NAICS. The CEFS covers the following criteria air pollutants:

- Total organic gases (TOG), as well as reactive organic gases (ROG) and volatile organic compounds (VOC) based on reactive fractions applied to TOG;
- Nitrogen oxides (NO_x);
- Carbon monoxide (CO);
- Sulfur oxides (SO_x); and
- Total particulate matter (PM), as well as primary particulate matter with an aerodynamic diameter less than or equal to 10 and 2.5 micrometers (PM_{10} and $PM_{2.5}$) based on size fractions applied to total PM.

Although it is not the emphasis of the CEFS, it is capable of projecting emissions for toxic pollutants as well. California geography can be specified for multiple levels of detail, from facility-level to State-level and many options in-between (e.g., by Air Basin/District/County). The system can also be used to output gridded projection inventories for air quality models. Because of the limits associated with the CEFS control factors, the system will be used to project through 2010, although growth factor data will be included through 2030.[1] The system will project from the emissions inventory data in CEIDARS, whose current base year is 1996. The system can also be used to back-cast emissions to 1970. Emissions can be reported on an annual, seasonal, daily, and hourly basis.

Model detail - The inputs to the model are varied. Baseline emissions are from CEIDARS, which is an Oracle relational data base system. Growth factors originate from a separate growth model, which is currently being developed. These factors are expected to predominantly

[1] Throughout this document, the term "control factors" is used to identify the combined effects of control efficiency (CE) and rule effectiveness (RE) on point source emissions, and CE, RE, and rule penetration (RP) on area source emissions.

represent county-level data, but the CEFS can handle facility-specific growth factors. Control factors are contained in a separate Rule Tracking Subsystem (RTS), which tracks controls at the process level (SCC/SIC code combination or Emission Inventory Code). The RTS includes control efficiency, rule penetration, and rule effectiveness information. The model also contains default temporal factors (for seasonal allocations for the TREND projection module and daily/ hourly allocations for the GIS module) and default ROG, VOC, PM_{10}, and $PM_{2.5}$ fractions. The temporal factor defaults for point and area sources are at the EIC level; data at the facility/device/ process level can be incorporated for point sources, however. Air quality management districts can supply their own TOG reactive fractions and PM_{10} and $PM_{2.5}$ fractions of total PM at the facility/device/process level for point sources; ARB defaults are SCC-specific. It should also be noted that CEFS has the ability to maintain default fractions by SCC for all years. This capability would allow the system to capture time-variation of reactive fractions when performing forecasts and backcasts (e.g., changes in organic composition of solvents). Model outputs include QA/QC reports on growth and control data, 17 standard reports including emission trends summarized by major source category, which can be used to report "growth-only" and "control only" scenarios, and several "special analysis" reports.

Comprehensiveness - With the exception of EPA's NONROAD model, the CEFS is as comprehensive as any of the models evaluated in this document in terms of incorporating each of the factors that affect future emissions. As noted above, it has the capability to model some process changes through its year-dependent reactive fractions structure (although it does not contain estimates for these fractions). For a small number of the larger source categories in the ARB inventory, ARB will incorporate the projected impact of technology/process changes in the CEFS' growth factors. For the top 50-emitting source categories in ARB's 1996 inventory, ARB is researching the availability of information on projected process changes. For example, information on reductions in organic solvent use in degreasing operations. The CEFS also models the impact of adopted regulations and can be used to model the effect of proposed measures through what-if scenarios. The CEFS does not explicitly model the effect that equipment turnover may have on future emissions.

Currency/ease of updates - For the most part, the CEFS model inputs are of recent vintage. The base year inventory has been recently updated in CEIDARS to, for example, merge toxic emissions with criteria pollutant emissions. The growth factors are currently being updated and should reflect forecasts based on information available for the year 2000. It is unclear from the documentation as to when the RTS information was last updated. It is also unclear how easy it will be for ARB to update most of the CEFS inputs. Most of the growth factors can be updated fairly easily as they are based on models for each California county that have already been developed and can be updated relatively easily given more up-to-date economic data. Many other growth factors will be based on independent analyses, some of which are expected to be updated on a periodic basis for other purposes (such as those conducted by the California Energy Commission), while others were developed specifically for ARB, and would require more substantial update efforts.

Documentation - A series of Air and Waste Management Association (AWMA) papers provides an overview of the CEFS. These lack much of the detail for a complete understanding

of the data inputs and nuances to each CEFS module. ARB is currently working to develop additional CEFS documentation, including documentation of the default growth factors.

b. Canada's Emission Forecasting Model (EFM)

Canada is currently developing its EFM to facilitate emissions forecasting under a variety of scenarios. The general construct of the EFM is a data base of base year emissions with user-supplied spreadsheet inputs reflecting projected growth rates, technology trends, fuel characteristics, and regulatory trends. The EFM has not been finalized and its future is uncertain due to resource constraints. At the time that this evaluation was conducted, there was no publically available documentation on the EFM.

Availability - The EFM was not finalized as of the time of this evaluation (the model contact suggested that the model be referred to as "Draft"). It is designed to be used with Canada's Residual Discharge Information System (RDIS) emissions inventory, and as such, is not generally available/applicable for use in the United States. The EFM will be a PC-based model running FoxPro software.

Coverage - The EFM is a National model that includes all emission source categories for five Canadian criteria air contaminants–VOC, NO_x, CO, sulfur dioxide (SO_2), and total PM. The model will also provide regional information (both province/territory and air quality management area forecasts can be developed). With the exception of baseline emissions, there is no default input data provided in the EFM. Therefore, the time horizon for which the EFM can develop forecasts will be dependent on the limits of the user-supplied inputs.

Model detail - Baseline emissions for Canada's forecasting model are from Canada's RDIS inventory (note that efforts to converting the 1995 RDIS inventory into the 1990 RDIS format used by the EFM are currently on-hold due to resource constraints). All other model input data are user-supplied. For example, users must supply all emissions growth inputs as spreadsheets in one user-created file. The user also creates the map between growth indicators and the base year inventory. Although users can supply EFM inputs at other regional levels, the EFM is set-up to allow users to supply inputs as detailed as the plant ID level. EFM emission forecasts are output at National, province/territory, or air quality management area geographic levels. EFM can create output emissions forecasts to an Access or spreadsheet file.

Comprehensiveness - Because the EFM does not contain default growth factor or control information, the comprehensiveness of the model with respect to the factors that affect future emissions will depend on the ability of the user to incorporate these concepts into the growth factor and control information that they supply to the model. The EFM notes that one scenario that can be implemented is to estimate the impact of "vintage effects" on future emissions by increasing emissions per unit of activity for any technology. Similarly, a "capital turnover" scenario could, for example, replace single-chamber solid waste incinerators with multiple-chamber incinerators.

Currency/ease of updates - This criterion is difficult to evaluate for the EFM because the only default input data for this model is the base year emissions inventory. For this input, however,

Canada is planning to incorporate the latest 1995 RDIS emissions when funding becomes available. This step will involve converting the 1995 emissions into the 1990 RDIS format upon which the EFM was designed. As noted above, other EFM inputs are user-supplied and their currency and the ease with which they can be updated will be based on the inputs that are supplied by the individual user.

Flexibility - The EFM appears to provide a significant amount of flexibility by allowing users to supply inputs at the plant ID level. Other indications of the flexibility of the model include the ability to develop scenarios that estimate, for example, the potential impacts of capital turnover on future emissions levels.

Documentation - There is no publically available documentation currently available for the EFM. Documentation may become available as the model is finalized.

c. ENERGY 2020

ENERGY 2020 is a software program developed by Systematic Solutions, Inc. (SSI) with assistance from Policy Assessment Corporation. ENERGY 2020 has the ability to model the following energy markets/concepts: residential, commercial, industrial, and transportation demand; electric and natural gas utility service; oil, coal, and natural gas extracting and refining; and renewable energy. Each ENERGY 2020 model is specifically developed to meet a client's needs. Basic model configurations include one or more demand sectors, a regulated electric utility sector, a simple supply sector, and an exogenous economic forecast designed to produce a utility demand forecast. But even basic configurations can vary. The energy demand structure in ENERGY 2020 is based off of the structure used in three models developed by the Electric Power Research Institute in 1982. The ENERGY 2020 demand sector was originally developed as a tool to evaluate electric utility demand-side management programs. It has since added a "pollutant accounting" module that estimates air pollutant emissions. Information on the ENERGY 2020 model is available from http://www.energy2020.com.

Because ENERGY 2020 is custom-designed for each user, this evaluation is based on general model information as well as information that was available on an ENERGY 2020 model that was designed for EPA's State and Local Climate Change Program. Unfortunately, the EPA model was not fully implemented, EPA's model license expired in 1999, and documentation of the EPA's model is limited.

Availability - The ENERGY 2020 model is proprietary SSI software. However, SSI states that the model can be freely given to others for review and critique. The cost of the custom-designed model will vary significantly based on the model's scope and level of energy market detail. SSI reports a $100,000 "ballpark" estimate for a county-level ENERGY 2020 model for one State. There was no additional cost to EPA for distributing their draft ENERGY 2020 model to State governments to assist them in assessing the impact of National greenhouse gas mitigation policies on their States. However, the EPA's ENERGY 2020 model license has since expired, and, therefore, EPA's model can no longer be distributed to the States.

ENERGY 2020 is a mainframe size simulation program. The ENERGY 2020 model runs under the PROMULA (PROcessor of MUltiple LAnguages) simulation system. PROMULA allows mainframe-sized models to run on microcomputers because of its ability to handle extremely large data bases quickly and easily. PROMULA allows programs written in any other language to run simultaneously with it. PROMULA is the only associated software required to run ENERGY 2020. The PROMULA code is machine independent (i.e., it can run on PCs or mainframe). The EPA version of ENERGY 2020 was a PC-DOS model, current versions are developed for Windows 98/NT.

Coverage - The basic ENERGY 2020 model forecasts energy supply and demand. In the simplest ENERGY 2020 configuration, a detailed demand module is combined with a simple macroeconomic sector and a simplified all-fuel supply sector. The standard demand sector disaggregates the three economic sectors (residential, commercial, and industrial) into sub-sectors based on customer or industry type and energy end-use. As many or as few sub-sectors can be supported as desired–divisions are custom-tailored to specific client needs. The default model simulates demand into three residential categories (single family, multi-family, and agriculture/rural), a commercial category, industrial categories by 2-digit SIC code, and three transportation service categories (residential, commercial, and industrial). There are approximately six end-uses per category (e.g., lighting) and six technology/mode families per end-use. ENERGY 2020 can support demand modeling for the following fuel types: electricity; gas; oil; liquefied petroleum gas (LPG); coal; biomass; and solar. The model can be developed at the region, State, utility service area, or county-levels. At the next higher level of detail, a single electric utility is often added to the model. At the most disaggregate levels, multiple suppliers of each fuel can be made to interact simultaneously. Similarly, demand may be broken into several customer classes, which are in turn disaggregated into numerous end-use groups. ENERGY 2020 covers the time period 1975 to 2020.

ENERGY 2020 includes a pollution generation module that tracks annual pollution by end-use and fuel type from each demand sector, and from the utility sector by supply and plant type. ENERGY 2020's pollution accounting module includes estimates of SO_2, nitrogen dioxide (NO_2), CO, total suspended particulates (TSP), VOC, tetrafluoromethane (CF_4), perfluoroethane (C_2F_6), sulfur hexafluoride (SF_6), and hydrofluorocarbon (HFC) emissions. ENERGY 2020's pollution accounting module tracks energy-related pollution in the industrial sector by 2-digit SIC code. The program also tracks the greenhouse gases carbon dioxide (CO_2), methane (CH_4), and nitrous oxides (N_20). Emission estimates are available for the level of detail at which the model is specified (i.e., region, State, utility service area, or county). Figure II-1 highlights the major interactions and feedback loops in ENERGY 2020's pollution accounting module. Additional details on the model's emission estimates are provided in the following sub-sections.

Emissions from Residential, Commercial, and Industrial Demand

ENERGY 2020 calculates emissions separately for each demand sector (i.e., residential, commercial, and industrial) so that levels for each pollutant can be viewed by sector, class, fuel, and end use where appropriate. Cogeneration emissions are also accounted for separately. Emissions attributed to new capital additions are treated separately as are emissions reductions attributed to capital retirements and retrofits. The net change is then added to current emission

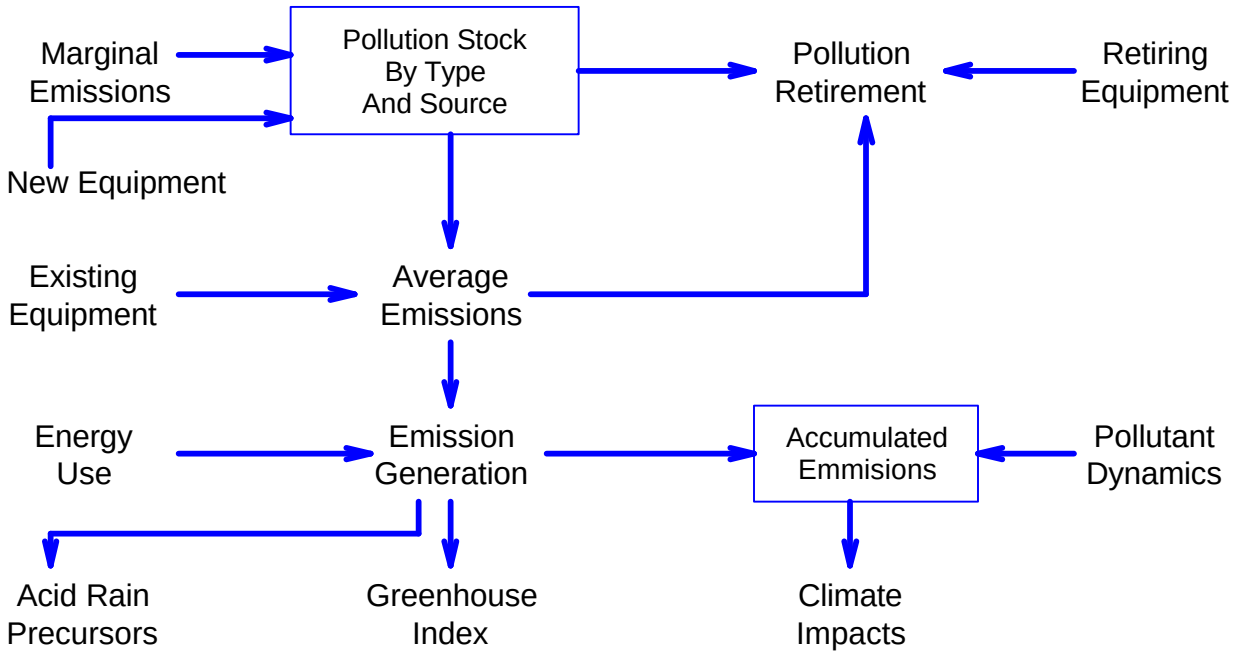

Figure II-1. Pollution Sector Structure

levels (termed "embedded" pollution by SSI). Emission reductions from retired devices are calculated as the product of the average (not marginal) pollution coefficient, which changes over time, and the energy requirement reduction due to retirement of energy using devices. Post-capital addition and retirement/retrofit emissions are termed "embodied" pollution, which is calculated by adding the net emissions change from pollution additions and retirements to embedded emissions. The average pollution coefficient is derived by dividing total embodied pollution by the total energy requirement measured in British thermal units (Btu) per year. While average pollution coefficients are calculated endogenously, emissions attributed to new capital additions and emission reductions from retrofits are calculated using marginal pollutant coefficients and standards that must be supplied by the model user. Both sets of coefficients are defined on an annual tons per Btu basis.

Cogeneration emissions are tracked separately but analogously to emissions from the three demand sectors (i.e., emissions are calculated separately for new, retired, and embodied pollution). For cogeneration, emissions are calculated using pollution coefficients and the product of new cogeneration capacity (MW per year), the cogeneration capacity utilization factor (Btu/Btu), and the cogeneration heat rate (Btu/kWh). Cogeneration emissions can then be summed in various ways (e.g., by fuel type and sector).

Electric Utility Emissions

Electric utility emissions are calculated by aggregating total electric utility fuel demand to the State level. The demand for fuel by plant type for electric utilities is determined by multiplying the electricity generated for each plant type by the average heat rate of that plant type. The demand

for fuel by plant type is converted into demand for fuel by fuel type. Total oil and gas demand is the sum of oil or gas used in coal plants, steam plants and combustion turbines. Gas demand is the fraction of oil and gas demand that is gas plus the fuel used for combined cycle plants. Oil demand is the fraction of oil and gas demand that belongs to oil. Coal demand is the fraction of fuel used in coal plants that is coal plus the coal used in advanced coal plants. Biomass fuel use is equal to waste fuel. Emissions from new additions are calculated by taking marginal pollution coefficients (or emission standards) and multiplying them by the demand additions. Emissions from retirements are calculated by multiplying the retirement pollution coefficient times the fuel demands associated with the retired plant. Emission changes due to controls are calculated by multiplying the embodied pollution in the prior year by one minus a "pollution control multiplier" that must be supplied by the user. Embodied pollution is determined by the prior levels of embodied pollution plus the net of pollution additions less pollution reductions due to plant retirements and retrofits. Therefore the pollution control multiplier is not applied to specific plants, but rather represents an average control across plants existing in the previous year and the net of new pollution and pollution reductions from plant retirements and retrofits.

As part of the design of the EPA Climate Change version of ENERGY 2020, EPA revised some of the model's pollutant accounting algorithms to take into account EPA emission estimation methodologies. As noted before, the EPA version of the model was never implemented, and documentation of these changes was not available.

Model detail - ENERGY 2020 includes internal National and State data bases that contain historical economic, price, and demand data by economic sector, fuel, and end-use. Energy supplier data comes from Resources Data International, Inc.; U.S. fuel demand data come from the U.S. Department of Energy (DOE). When available, regional and utility-specific data override and supplement the aggregate data. ENERGY 2020 requires economic inputs as drivers. ENERGY 2020 works with either exogenous economic drivers from any economic forecast or through links with an economic model. Often times, as with EPA's model, ENERGY 2020 is linked to Regional Economic Models, Inc. (REMI) economic models, which allows energy prices and price changes generated in ENERGY 2020 to interact dynamically with REMI's economic forecast. The forecast economic changes can then flow back to ENERGY 2020, affecting future demand, utility rates, and resource planning. Personal income and gross output by industry from the REMI model are the principal drivers for ENERGY 2020. Other REMI variables used in the ENERGY 2020 data bases include population, new capital investment, Gross State Product (GSP), and employment. Different demand sectors are principally driven by different drivers. For example, personal income is the principal driver for the residential sector, while gross output by industry is the principal driver for the commercial and industrial sectors. Models can be developed at the county-level, although most past models have been designed at the State level. Table II-1 presents an example ENERGY 2020 summary output report for residential demand.

It is important to note that ENERGY 2020 was not originally developed as an emission projections model. Therefore, it is not set-up to use a base year emissions inventory as a starting point. A scoping study would be required to determine the feasibility of incorporating base year emissions inventory information with the pollution projection algorithms in the model.

Table II-1. ENERGY 2020 Residential Summary Demand Report

Demand Summary
Base year is 1988, Demonstration model, 1988 to 2000
Residential

	1988	1990	1995	2000
Personal Income (M$/YR)	4,736	5,075	5,719	6,517
Income Growth Rate (%)	0.00	3.45	2.69	2.66
Total Demand (TBTU/YR)	29.00	30.60	35.23	39.89
Demand Growth Rate (%)	0.00	2.69	2.78	2.66
Energy Income Ratio (BTU/$)	6,122	6,029	6,161	6,122
Demand (TBTU/YR)				
Gas	1,981	1,885	2,394	2,760
Oil	10.990	11.396	13.794	16.139
Coal	0.100	0.154	0.227	0.214
Biomass	6.504	6.801	6.582	5.975
Solar	0.055	0.065	0.087	0.118
Electric	6.968	7.744	9.072	11.015
LPG	2.398	2.554	3.078	3.671
Demand Growth Rate				
Gas	0.00	-2.48	2.71	2.76
Oil	0.00	1.81	3.25	3.20
Coal	0.00	21.60	11.74	6.34
Biomass	0.00	2.23	0.17	-0.71
Solar	0.00	8.05	6.61	6.38
Electric	0.00	5.28	3.77	3.82
LPG	0.00	3.16	3.57	3.55
Energy Income Ratio (BTU/$)				
Gas	418	372	419	423
Oil	2,320	2,246	2,412	2,477
Coal	21	30	40	33
Biomass	1,373	1,340	1,151	917
Solar	*12*	13	15	15
Electric	1,471	1,526	1,586	1,690
LPG	506	503	538	563

Comprehensiveness - The ENERGY 2020 appears to be comprehensive in providing algorithms to estimate emissions changes due to equipment retirement, emission regulations, and projected plant type and fuel use changes. It is important to note that the model does not include default parameters for the impact of these changes. In addition, ENERGY 2020 develops emission projections using its own, less detailed base year emissions information.

Currency/ease of updates - SSI documentation states that the ENERGY 2020 framework automatically calibrates to a specific area with minimal data requirements, and that much of the data in the model's default data bases are specified by State. SSI also reports that annual updates to the model require minimal effort.

Flexibility - ENERGY 2020 claims that its model framework provides an important flexibility advantage over other models. SSI notes that new sectors can be added and old ones modified by the user without upsetting the interactions already in the model. ENERGY 2020 allows an arbitrary number of end-uses, fuels, technologies, suppliers, and demand market segments. In addition to over 100 pre-defined reports and graphs, including tables of demand levels, SSI can

modify the report formats to suit the individual needs of each client. ENERGY 2020 allows users to modify model parameters. In addition, the modular design of ENERGY 2020 lets users replace any portion of the model with their own application. ENERGY 2020 also performs scenario analyses that can be used to evaluate alternative inflation, economic growth, technology and regulatory scenarios. The scenarios can be tested individually or in combinations.

Documentation - In terms of energy supply and demand modeling, the documentation provided for this evaluation was general in nature and did not provide specifics as to model algorithms and operation. Model algorithms were available for the pollution accounting module. However, little information was provided on the pollution coefficients that are key to this module. A past EPA user commented that documentation was sparse and out-of-date. This user viewed ENERGY 2020 as a "black box" model whose operation was not well understood. It may be difficult to attain sufficient public scrutiny of the model's algorithms based on previous EPA experience with ENERGY 2020.

d. Multiple Projections System (MPS)

The EPA developed the MPS to assist State and local air agencies in performing "what-if scenario analyses" and developing their reasonable further progress (RFP) inventories. The MPS is designed to facilitate the projection of future emissions of ozone precursors, specifically VOCs, NO_x, and CO in any given geographic area. The MPS was last updated in 1995; background information on the model is available from the following web address: http://www.epa.gov/ordntrnt/ORD/WebPubs/projsum/600sr9425.pdf.

Availability - As an EPA product, there are no proprietary/licensing or cost issues associated with of the MPS. The MPS was developed under Windows 3.1, using Superbase 4, a data base package that could be compiled and distributed as a stand-alone product. System requirements are modest: a 386SX processor and at least 4 MB of RAM; required disk space is dependent on the number and size of the geographic areas studied.

Coverage - The MPS does not contain default emissions, growth factor, or control data that can be used to evaluate the model's coverage. MPS users must provide the necessary base year emissions, growth factor, and base and projection year control efficiency, rule effectiveness, and rule penetration values. The model is constrained by its focus on ozone precursor emissions only. MPS can be used for any area of the country with the necessary input data. The geographic coverage of MPS includes State, county, and nonattainment area. It is not designed for use with emissions grids for air quality modeling. MPS can report emissions data on an annual, seasonal, monthly, and daily basis. The model covers the period 1990-2010.

Model detail - MPS users must import 1990 emissions data from files retrieved from the Aerometric Information Retrieval System (AIRS). In particular, base year (1990) emissions data for MPS are imported by the user from data files retrieved from the AIRS Facility Subsystem (AFS) and AIRS Area and Mobile Subsystem (AMS). MPS assumes that users will import EGAS SCC-based growth factor files and on-road mobile source emission factors from EPA's MOBILE5 model, and will modify the stationary source base year control efficiency (CE), rule effectiveness (RE), and rule penetration (RP) data from AIRS to reflect future year CE, RE, and

RP (RP data are only in the AMS files). Users can modify the growth factors, the projected CE, RE, and RP for each record in the AIRS base year file (i.e., each unique point/stack ID for point sources, each SCC for area sources). Users can also enter new sources into MPS, and will need to input all associated control information since information from new sources is not available in AIRS.

Projections data from MPS can be exported to Lotus, DBase3, or Excel. Results are reported in projected emissions for each year or in percentage relative to base year emissions. MPS has three output device options: (1) to screen; (2) to printer; and (3) to ASCII file. MPS output can be prepared in either tabular report or graphical format (graphical format option does not support output to an ASCII file). Three types of tabular reports are available: (1) summary; (2) full (point and group totals); and (3) by EPA's Tier emissions category system.

Comprehensiveness - Because the model relies on user inputs for growth and future year control assumptions, the ability of the model to factor in equipment turnover, technology/process changes, and emission regulations is dependent upon whether user inputs factor the effect of each of these concepts on future emissions.

Currency/ease of updates - As noted above, MPS relies on user inputs for its data. The major problem with MPS is that it was last supported in 1995. As such, it was developed to use a 1990 base year emissions inventory for ozone pollutants, and to specifically employ AIRS data files. The EPA's Office of Air Quality Planning and Standards (OAQPS) has announced plans to retire the emissions portion of AFS on September 30, 2000 and migrate internal tracking of emissions inventories to the National Emissions Trends (NET) data base. The NET will store point, area, mobile, and biogenic data for criteria and toxic pollutants. Therefore, future use of MPS would require substantial revisions to make the system compatible with future EPA file formats (e.g., EPA's NET input format).

Flexibility - The MPS is flexible in that users can apply growth and control assumptions for each facility. It is inflexible in that it is designed to run with AIRS data file formats and only supports ozone precursor emissions. The program is flexible in that it allows both interactive and batch mode processing. Batch mode allows users to set-up multiple runs and have the MPS execute them unattended.

Documentation - MPS is well documented given the lack of input data it requires and the fact that it relies on standard data input files (e.g., AIRS and EGAS data). Because model algorithms are few and straightforward, the model requires less documentation to explain its operation than some of the other projection models.

e. EPA's NONROAD Model

The EPA is currently developing the NONROAD model to develop base and projection year emission estimates for most, but not all, nonroad source categories. To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. The latest draft version of the NONROAD model was

posted on June 12, 2000, and can be found at the following web address: http://www.epa.gov/otaq/nonrdmdl.htm.

Availability - As an EPA model, NONROAD is not proprietary, and there are no licensing or cost issues associated with its use. NONROAD is designed to run on a personal computer (PC) under Windows 3.1 and 95/98. Hardware requirements are: 486 Mhz processor, 16 Mb RAM, and 30 Mb hard disk space.

Coverage - The NONROAD model covers the following equipment categories: 1) agricultural; 2) airport support; 3) light commercial; 4) construction and mining; 5) industrial; 6) lawn and garden; 7) logging; 8) pleasure craft; 9) railroad; and 10) recreational. The model includes more than 80 basic and 260 specific types of nonroad equipment, and further stratifies equipment types by horsepower rating. Fuel types include gasoline, diesel, compressed natural gas (CNG), and LPG. It is important to note that aircraft, locomotives, and commercial marine categories are currently not included in the NONROAD model; future model updates are expected to cover these categories. The NONROAD model does not contain any SIC or NAICS information. Exhaust pollutants are reported for all criteria pollutants, plus CO_2. The model includes both exhaust and evaporative emissions for the following hydrocarbon species: total hydrocarbons, non-methane hydrocarbons, VOC, TOG, total methane organic gases. Non-exhaust hydrocarbon pollutants include diurnal, refueling, spillage, and crankcase emissions. The model calculates emission inventories on an annual, seasonal, or daily basis.

The model develops historical emission estimates starting with 1970 and can project nonroad emissions through the year 2045. In each run of the model, the user selects what geographic area(s) are to be included. At the broadest level, the model estimates National total emissions. Users can also specify emissions by State, or for one or more counties within a State. At the most detailed level, the user can estimate sub-county emissions; however, this is an advanced feature and the user must supply sub-county input data. The user also has the option to generate an EPS input file. EPS can take the county-level output from the NONROAD model and create gridded emissions files ready for input to the UAM, a photochemical grid model.

The NONROAD model can calculate emissions for a variety of time periods — an entire year, one of four seasons, or any particular month. Emissions for the period selected are estimated either for the total period or for a typical day (weekday or weekend) in that period.

Model detail - The NONROAD model estimates equipment populations distinguished by rated horsepower, and multiplies these values by the hours of use, load factor, and emission factor.

The NONROAD model uses national equipment population data from Power Systems Research (PSR), a company that tracks the sales and populations of all types of nonroad equipment sold in the U.S. Power Systems Research is a leader in global market research of nonroad engine applications. They have developed the *North American Engine PartsLink Data Base* (hereafter referred to as *PartsLink*), which estimates engine replacement rates and parts consumption profiles for the United States. This information is generally used by equipment manufacturers and suppliers for product planning purposes. As a component of *PartsLink*, PSR

has developed annual nonroad engine populations by application, horsepower (hp), engine type (i.e., spark-ignition or compression-ignition), and the number of strokes per engine cycle (2 or 4). It should be noted that PSR also matches the engines to the equipment in which they are used. PSR updates these data on a yearly basis.

In general, PSR estimates engine populations using the following procedure: 1) determine the number of engines sold for a specific year, accounting for imports and exports; 2) obtain data on mean engine life, average annual hours of use, load factor, and horsepower; 3) develop an attrition curve that relates the percent of units remaining in service to the percent of expected life not yet consumed; 4) determine the number of engines still in service for each model year population (i.e., engines placed in service during the same year) according to the attrition curve; 5) sum up the number of engines operating for each appropriate year to arrive at a total population for the year in question; and 6) allocate national populations to a county level using economic surrogate data. More detail on PSR's methodology for estimating nonroad engine populations, including limitations of the PSR data and recommended areas for improvement, is provided in "Evaluation of Power Systems Research (PSR) Nonroad Population Data Base, Revised Draft Report," September 1997. Prepared by Pechan for the U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI.

The PSR data base geographically allocates equipment populations (actual data for 1998, other years estimated) from the national to the county level and then aggregates the county-level populations to generate State totals. The NONROAD model assumes that each type of equipment experiences the same annual activity (i.e., rated horsepower times load factor times annual hours of use), which simplifies the nonroad activity allocation to one of allocating equipment populations. The methods and data that PSR uses to perform these allocations were not available in detailed form because PSR considers their methods to be proprietary information. Since EPA wants the methods that are used to allocate equipment populations in NONROAD to be fully transparent, EPA uses publicly available data as much as possible to allocate the national PSR equipment populations to the county level. These allocation factors are based on surrogate indicators such as harvested cropland for allocating agricultural equipment. Other specific data sources are used for the population of recreational marine vehicles, snowmobiles, lawn and garden equipment, and forklifts. EPA encourages State and local users to substitute well-documented, specific local (e.g., county, nonattainment area) equipment population data in place of the model's default inputs to increase the accuracy of the resultant inventories.

The growth factors in the model represent the projected equipment populations. These factors, which are National, are differentiated by nonroad application (e.g., construction vs. farm) and fuel type (e.g., gasoline vs. diesel). The growth factors were generally developed by extrapolating from a linear regression of PSR National equipment population estimates for 1989-1996. Exceptions include oil-field equipment (Bureau of Economic Analysis [BEA] projections) and airport ground support equipment (landing and take-off projections).

Engine activity (rated horsepower times load factor times annual hours used) data are also based on National level data from PSR's data base (exceptions are recreational marine, and lawn and garden). Engine scrappage estimates are based on a normal distribution and median engine life data from an Environmental Energy Analysis, Inc. analysis of PSR's data base.

The effects of emission standards are reflected in the NONROAD model emission factors (which are expressed in units of mass emissions per horsepower-hour). The emission factors are distinguished by rated horsepower since Federal nonroad standards apply based on the size (i.e., horsepower) of the engine. NONROAD emission factors account for the effect of Federal control programs, and do not reflect any potential local controls.

As indicated above, much of the input data in NONROAD are based on National estimates. For example, potential differences in State and local growth rates are not reflected in the model. The model, however, does allow users to revise the National default data to reflect local data that may be available.

The NONROAD reporting utility provides the user with eight types of standard reports:

- Emissions Totals by County;
- Emissions Totals by Equipment Type;
- Emissions Totals by Horsepower;
- Emissions Totals by SCC (source category code);
- Emissions Totals by SCC and Horsepower;
- Emissions Totals by Source Classification;
- Population and Fuel Consumption by SCC; and
- Population and Fuel Consumption by SCC and Horsepower.

For most reports, emissions can be reported for either all counties or for a single, user-specified county. Reports that include emissions estimates by equipment types or by SCC are separated by major source classification (e.g., agricultural, lawn and garden), with subtotals provided for each classification. For those reports, equipment type descriptions are also included (e.g., 2-wheel tractors, asphalt pavers, etc.). Where appropriate, reports also include a grand total by pollutant.

Comprehensiveness - The NONROAD model is perhaps the most comprehensive emission projections model evaluated in this paper. NONROAD accounts for equipment scrappage wherein existing nonroad equipment is retired and replaced with new equipment that emits at lower levels due to new emission standards. The NONROAD model estimates emissions for each specific type of nonroad equipment by multiplying the following input data estimates:

- Equipment population for base year (or base year population grown to a future year), distributed by age, power, fuel type, and application;
- Average load factor expressed as average fraction of available power;
- Activity in hours of use per year; and
- Emission factor with deterioration and/or new standards.

The emissions are then temporally and geographically allocated using appropriate allocation factors. There are several input files that provide necessary information to calculate and allocate emissions estimates. These input files correspond to the basic data needed to provide the calculations: emission factors, base year equipment population, activity, load factor, average lifetime, scrappage function, growth estimates, and geographic and temporal allocation. The

model also includes deterioration factors that estimate rates of emission increase as nonroad equipment ages.

One potential effect that NONROAD does not include is that scrappage rates of existing engine populations may decline if new engine standards create an incentive for nonroad equipment operators to use existing equipment for longer periods. Other activity level variables that may change due to stricter emission standards for new engines include average rated hp and load factor. Given the numerous variables it includes, however, the NONROAD model does an excellent job of modeling the various factors that impact future nonroad emission levels.

Currency/ease of updates - The NONROAD model is still under development, so an analysis of the recentness of the inputs in the current draft model may not be representative of the inputs associated with the final model. For example, EPA has already updated the PSR equipment population data in the model once since the first draft model was released. Other changes have occurred to the growth data in the model. Potential model user's should investigate the recentness of the model inputs, which are described above, at the time of model use.

Flexibility - The NONROAD model was designed to allow substantial levels of user flexibility. Any of the model parameters (e.g., scrappage function) described in the *comprehensiveness* section above can be changed by the model user. The model is modular in the sense that the model is made-up of a series of "packets" that the user selects to run. The model also allows users to run the model for specific geographic areas and source categories.

Documentation - The draft NONROAD model and model development process has been very well documented by EPA. A series of more than 20 reports have been produced on the model, its operation, and default data sets. These reports can be accessed on the world wide web at: http://www.epa.gov/otaq/nonrdmdl.htm

2. Emissions Modeling Tools

This section describes and analyses three prominent emissions modeling tools used to develop projected emissions data for use in air quality modeling: the EPS, the EMS-95, and the SMOKE modeling system.

a. Emissions Preprocessor System (EPS) 2.5

EPS consists of a series of FORTRAN modules that perform data manipulations to incorporate spatial, temporal, and chemical resolution into an emission inventory used for photochemical modeling. The modules are classified into four major components: (1) core EPS modules; (2) input preparation utilities, (3) support utilities to manipulate the internal record format, and (4) reporting utilities. One of the 10 core EPS modules, CNTLEM, performs emission projections by reflecting the impacts of anticipated growth and controls on future emission levels. The focus of the evaluation of EPS will be on the CNTLEM module. For information on the other core EPS modules, including the temporal and spatial allocation modules, major EPS components, and interface and emissions display system the reader should refer to "User's Guide for the Urban Airshed Model, Volume IV: User's Manual for the

Emissions Preprocessor System 2.0, Part A: Core Fortran System and Part B: Interface and Emission Display System," EPA-450/4-90-007D(R), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, June 1992. Summary background information on EPS 2.0 can be found at http://www.epa.gov/asmdnerl/eps.html.

Availability - EPS is an EPA-sponsored, non-proprietary model that processes a county-level annual or seasonal emission inventory for use in photochemical modeling. Version 1.0 of EPS was released to the public in 1990. The EPA has funded a series of enhancements to the model, culminating in Version 2.5. Unfortunately, documentation has not been developed for this Version of EPS, so this EPS evaluation is based on documentation for Version 2.0. Conversations with an EPS developer indicate that the main change from EPS 2.0 to EPS 2.5 is in how the model handles data arrays.

EPS hardware and software requirements are: IBM mainframe (EPS can also be converted to run on UNIX) and a FORTRAN-77 compiler. To use the EPS interface and emission display system, users must have base SAS software 6.07, SAS/AF, SAS/GRAPH and United States map data sets.

Coverage - For the most part, the EPS model does not contain data inputs, and therefore the coverage of the model will largely be determined by the data inputs supplied by the user. The model handles point source projections separately from area/mobile sources and includes the following pollutants: VOC, NO_x, CO, SO_x, TSP, and PM_{10} (VOC and NO_x are speciated in a separate EPS module). The EPS is based on the use of SCCs and SIC codes, and does not include NAICS data. With EPS' speciation module (GRDEM), the EPS can output emission projections at the grid cell-level for air quality modeling. EPS also provides county-level output. The temporal coverage of EPS is based in part on the coverage of the user-supplied base year emissions inventory, although EPS includes a temporal allocation module that adjusts emissions from annual, seasonal, or typical season day to hourly levels for use by the UAM. The time-frame covered by the model is largely dependent on the user-supplied control factors; default growth factors are available through the year 2045.

Model detail - EPS does not contain default emissions inventory data. Default EPS growth factors, which are from the BEA regional projections series, are State level. However, users can supply factors as specific as the county/SCC or county/SIC code level. There is no default control factor information in EPS, although the model will automatically determine whether to apply reasonably available control technology (RACT) controls (affecting VOC and NO_x emissions) and maximum achievable control technology (MACT) controls (affecting VOC emissions) based on the total emissions for a facility and the criteria which are specified within the CNTLEM source code. For control technique guideline (CTG) controls, the user must specify an emissions cutoff level which CNTLEM uses to assess CTG applicability at the source. EPS allows users to supply control information (i.e., control efficiency, rule effectiveness, and rule penetration factors) as specific as individual facilities/stacks. The identification fields for the control information are: FIPS code; subregion code; SIC code; SCC code; facility identification code; stack identification code; and primary equipment code.

Comprehensiveness - Because of the lack of default information in EPS, the comprehensiveness of this model concerning the extent to which it accounts for each of the factors that affects future emissions (e.g., equipment turnover, technology/process changes, emission regulations) will depend on the ability of the user to include these factors in the control factor information or in user-supplied growth factors that would over-ride the default BEA factors (the BEA factors are defined on economic sector, rather than emission sector terms; these factors, therefore, do not explicitly model the effect of technology/process changes on emissions growth).

Currency/ease of updates - This criterion is difficult to evaluate because of the lack of default data included in the system. With the exception of the default BEA emissions growth data, the currency/ease of updating EPS inputs will depend on the inputs that are supplied by the user. Because the BEA's last set of projections data were released in 1995 and there are no plans for future updates, this set of input data receive a poor ranking for this criterion.

Flexibility - EPS facilitates flexibility by allowing the user to input both source-specific inputs and default inputs. If detailed data are available for only a single source in the modeling domain, EPS allows the data to be used without requiring that all sources have data at the same level of detail. EPS is designed to run in a modular function. After the first three modules, which serve as entry points to EPS for point source, area and mobile source, and link-based mobile source data, are run, certain other modules can be run in any order: CNTLEM, CHMSPL (which speciates emissions), TMPRL (which temporally allocates emissions), and GRDEM (which spatially allocates emissions). Therefore, CNTLEM can be run without speciating or temporally or spatially allocating emissions. The reporting module, which includes output capability by SCC, SIC, and Tiers, can be executed at any stage of processing.

Documentation - EPS 2.0 is well documented in EPA reports and supporting materials (e.g., model change bulletins). Currently, no documentation has been developed for EPS 2.5.

b. Emissions Modeling System (EMS)-95

EMS-95 is an emissions modeling system designed to develop emissions estimates for urban- and regional-scale photochemical and PM_{10} dispersion models. EMS-95 prepares gridded, hourly emissions for criteria air pollutants for stationary and mobile emission sources. There are nine models that comprise EMS-95. Each of the nine models is composed of one or more modules, which are in turn composed of one or more processors. These processors are the computer programs (written in SAS, ARC/INFO, and FORTRAN) that perform the emission projection/control, spatial allocation, temporal allocation, and speciation functions of the modeling system. The projections "model" is not an independent model in EMS-95; the functions of this "model" are performed as part of each individual emission estimates model (i.e., Point Source Model, Area Source Model, Motor Vehicle Emissions Estimates Model, and Crude Oil Storage Tank Model). The EMS-95 User's Guide is available at the following web address: http://www.ladco.org/emis/guide/ems95.html.

Availability - With the exception of some minimal tape/media fees, EMS-95 and its data are free and publicly available from the Lake Michigan Air Directors Consortium (LADCO).

EMS-95 is currently able to run on UNIX workstations running SAS software. The estimated cost for a SAS license on a UNIX workstation is $35,000. The SAS license must include SAS GRAPH and SAS FSP; SAS INSIGHT is recommended for visualization. Minimum UNIX workstation requirements are: 512 Mbytes RAM; 30 Gbytes SCSI disk storage; 8 mm Exabyte tape drive or DLT drive; and a 150 Mhertz RISC CPU, which is not the same as a 150 Mhertz Intel CPU. Note that more disk storage may be required depending on the number of grid cells and number of modeling days. LADCO currently uses SUN workstations, if DEC workstations are to be used, there are some data conversions that are required, but LADCO States that these should only take a few hours. Other requirements include FORTRAN (to compile MOBILE5b once) and an ARC/INFO license or other way to develop spatial surrogates. LADCO plans a future PC Windows NT version of EMS (EMS-2000) that is expected to require a 450 Mhertz Intel processor with 256 Mbytes of RAM and equivalent ultra-SCSI drives as the UNIX systems. Note that the PC version will have a significant cost advantage over the UNIX workstation in that the cost of the PC SAS license is approximately $5,000.

Coverage - EMS-95 prepares gridded, hourly emissions for criteria air pollutants. EMS-95 includes point, area, motor vehicle, and biogenic emissions (there is no projection component for biogenic emissions). The emissions modeling grid structure is generated in EMS-95 by the grid definition model. The model is generally not constrained by endogenous parameters, the geographic, temporal, and source category coverage are a function of the user-supplied model input data. However, the model only includes the following criteria pollutants: NO_x, SO_x, CO, PM, TOG, and only develops grid-level emission estimates.

Model detail - The growth model in EMS-95 projects emissions from existing sources to the future year of interest by applying a scaler factor. Base year emissions, growth factors, and control factors must be supplied by the user. Base year emissions input file requirements are specific to point sources, area sources, and motor vehicles:

- Point sources - five files are needed: facility, stack, device, process, and emissions; these files contain stack, activity, and emissions information for each point source.

- Area sources - two files are needed: temporal and emissions; these files contain activity and emissions information for each area source category.

- Motor vehicles - five files are needed: vehicle miles traveled (VMT), spatial (coordinates of links and outlines of transportation networks), temporal (seasonal, daily, and hourly VMT profiles), meteorology, and MOBILE5 inputs.

EMS-95 requires either annual average or typical summer day emission inputs for point and area sources; it is not capable of calculating these emissions. EMS-95 calculates emissions for on-highway vehicles by multiplying the activity level (expressed as VMT) times the emissions factor (expressed as grams per mile (g/mi)).

EMS-95 requires user-supplied growth and control factors. For the point and area sectors, these factors are then applied to the base hourly emission estimates, which are generated through the temporal allocation process. For point sources, these factors can be applied by a variety of

combinations of State, county, facility, device, and pollutant identifiers as well as by SCC and SIC code; for area sources, these factors are applied by the same identifiers except for the facility, device and SIC code. EMS-95 contains a hierarchy of combinations for which growth and control factors can be applied to the base hourly emission estimates. This hierarchy, which is listed from the most specific to the broadest application, is described in the EMS-95 technical documentation (See James G. Wilkinson, *et al.,* "Technical Formulation Document" dated December 21, 1994). The hierarchy permits application of factors by SCC or SIC code only and by SCC and SIC code combination as well. For point sources, SCC-based factors can be applied at the 1-, 3-, 6-, and 8-digit levels; SIC code-based factors can be applied at the 1-, 2-, and 4-digit levels. For area sources, SCC-based factors can be applied at the 2-, 4-, 5-, 7-, and 10-digit levels. For point sources, growth factors can be applied at the facility ID and device ID levels; pollutant-specific control factors can also be specified at these levels. Control factors are specified using control efficiency, rule effectiveness, and, for area sources only, rule penetration values. The output of the point and area source models in EMS-95 are gridded, hourly emission inventories for criteria pollutants.

For motor vehicle emissions, EMS-95 requires VMT and speed data, spatial (network links, outlines of transportation networks, and other polygon-related) data, and emissions factors (from the MOBILE5 model). The required VMT input files depend on whether the VMT data represent on-network VMT, off-network VMT, or public land survey quarter section-based VMT. The growth and control factor information, which are supplied by the user, are applied to the base year emissions estimates using either State and county identifiers or simply the State identifier. Control information is developed by developing future year emission factors from the MOBILE5 model. The output of the motor vehicle model is a gridded, hourly emissions inventory for TOG, NO_x, and CO, which can then be input to the EMS-95 speciation model.

Comprehensiveness - Point source start-ups and shutdowns can be accounted for by modifying the base year inventory. The control model in EMS-95 adjusts emissions to reflect control measures for point and area sources by applying several control factors (i.e., control efficiency, rule effectiveness, rule penetration, source conversion factor, and process unit growth). Information for each factor is supplied by the user via spreadsheet or source-specific file. Control measures for motor vehicles are accounted for by the MOBILE5 model. EMS-95 also allows modeling of replacement equipment/processes whereby a user inputs control factor information for a "new_SCC" that is linked to a set of SCC records in the base year inventory. Because the user supplies the growth and control factors to EMS-95, the comprehensiveness of the model with respect to estimating the impact of each of the factors that affects future emissions (e.g., equipment turnover) is dependent upon the ability of the user to incorporate these effects into the growth and control factor files.

Currency/ease of updates - This criterion can not be evaluated because of the lack of default data included in EMS-95. The currency/ease of updating inputs will depend on the inputs that are supplied by the EMS-95 user.

Flexibility - The model is flexible in that users provide most of the input data and can apply growth and control factor inputs at various levels of detail, including facility level for point sources. The model is not flexible in that the base year emission inventories must first be

processed into gridded inventories before developing projection inventories. This structure is explained by the purpose for which EMS-95 was developed–for developing emission inventory data for use in air quality modeling.

Documentation - Documentation for EMS-95 is fairly complete, although documentation of the projections processing is not up-to-date. However, LADCO plans to update the documentation of the projections methodologies as part of forthcoming documentation for EMS-2000.

c. Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System

The Microelectronics Center of North Carolina (MCNC) has created the SMOKE Modeling System to create an emissions model that integrates high-performance-computing (HPC) sparse-matrix algorithms. The SMOKE system provides a mechanism for preparing specialized inputs for air quality modeling. SMOKE is partially integrated with EPA's Models-3 system, and work is ongoing to complete that integration process. The current version of SMOKE is primarily an emission processing system and not an emission inventory preparation system. This means that, with the exception of mobile sources, its purpose is to provide an efficient tool for converting emissions inventory data into the formatted emission files required by an air quality model. For mobile sources, SMOKE additionally computes an emissions inventory from mobile-source activity data (i.e., VMT), using emission factors. To obtain comprehensive documentation of SMOKE, readers can access the information provided at the following web address: http://www.iceis.mcnc.org/products/smoke.

Availability - SMOKE, which runs on a UNIX platform, is freely available for download and use from MCNC's North Carolina Supercomputing Center web-site at http://www.iceis.mcnc.org/edss/edss_register/EDSS.download.html. The system currently runs on a Sun workstation with SunOS 5.6, an SGI workstation with IRIX 6.5, compiled for either 32- or 64-bit; and an IBM AIX4 (SMOKE developers state that the model will not run efficiently on an older workstation). Developers are now working on an HP version; a Windows NT version is also planned. At least 132 Mb of memory is required.

MCNC does not provide SMOKE support to the general public. Third party software is not required to run SMOKE, although some input file preparation may require other software. The SMOKE User Manual does not provide technical documentation on the code itself, but the code has extensive documentation to assist experienced Fortran users in understanding its workings.

Coverage - SMOKE Version 1 supports area, mobile, and point source emission processing and also includes biogenic emissions modeling through a rewrite of the Biogenic Emission Inventory System, version 2 (BEIS2). To allow flexibility in modeling ozone, particulates, or toxics, SMOKE supports user-selected inventory pollutants. The SMOKE programs do not have any pollutant names or characteristics coded directly into the programs. With two exceptions, this information is provided by the input files when the user runs the programs. The first exception is for mobile sources, which rely on emission factors from the MOBILE5 program. The second exception is for biogenic emissions, which relies on the BEIS2 model. There is, however, a maximum number of SMOKE pollutants allowed: 19 for area sources; 54 for mobile

sources; and 15 for point sources. SMOKE can apply any chemical mechanism to partition pollutants to model species, as long as the appropriate input data are supplied. SMOKE can also speciate emissions into up to 120 user-selected species.

Although the SMOKE emission inventory input files can carry SIC code information, NAICS code information is not currently supported. In addition, the system does not currently support projections based on SIC code growth factors, although the point-source projection format has been designed to use both SIC and SCC-based growth factors.

Based on spatial processing in SMOKE, the program can develop grid-level emissions for any number and size of grid cell. SMOKE can optionally output State and county total emissions.

For area sources, SMOKE processes emissions in one of two input formats: annual or average daily; point sources are processed using one of three input formats: annual, daily, or hourly (the SMOKE user supplies the emissions input files). SMOKE can output emissions based on these input formats as well as area and mobile sources on an hourly basis based on temporal profiles supplied by the user. The historical and future year time-frame covered by SMOKE will depend on the base year emissions inventory inputs and the user-supplied growth and control information.

Model detail - SMOKE, which currently relies on user-supplied emissions data, supports the Inventory Data Analyzer (IDA) format for area, mobile, and point source emission inputs, and the EMS-95 format for area and point source inputs. SMOKE has also been designed for future implementation of the EPS 2.0 inventory input format. Future plans are to package SMOKE with the NET inventory.

SMOKE imports user-supplied growth and control factors to create a growth matrix and control matrices, which are then applied to the inventory. SMOKE records are grouped according to the "level" of matching of each of the entries. For example, all entries that match to the inventory using only State and county codes would be in one group, while entries that match to the inventory using only SCCs would be in another group. Once the cross-reference entries are grouped, SMOKE loops through all records in the inventory, and attempts to find a matching entry in one of the cross-reference groups. The most specific groups are searched first, such that when a match is found, the other groups are not searched. When a match to one of the cross-reference groups has been found, SMOKE continues to the next source in the inventory. For area sources, speciation, temporal allocation, projection, control, and spatial allocation are implemented using an emissions cross-reference and profile approach in which each county and SCC code is assigned a profile number by using a cross reference file. For point source processing, each county, SCC code, plant ID, and stack ID is assigned a profile number by using a cross-reference file. For mobile sources, this cross-reference file is specified by county, road class, and link. A given profile number is used to find the appropriate temporal profile, speciation profile, etc., that transforms the SMOKE input data using factors from the profiles.

The projection matrix contains future year projection factors for all sources. The SMOKE projection format has been designed to apply growth factors at the 4-digit SIC level and the 10-digit SCC level (although SIC code matching is not yet supported). SMOKE only supports

State or county-level growth factors. Emission controls are specified in SMOKE using control efficiency, rule effectiveness, and rule penetration values. Controls for area sources are specified by county and SCC. Point source emission controls can be specified at the emissions segment level. Future year mobile source emission factors from MOBILE5 can be specified by State, county, road class, and link.

SMOKE can apply any number and size of grid cells. For area sources, surrogate indicators are used to allocate emissions to grids; point sources are assigned to grid cells based on their location; mobile sources can either apply surrogate spatial indicators, map link sources to grid cells, and/or apply a link definition file. SMOKE contains its own line-grid intersection code to divide mobile source link emissions into each grid cell.

Comprehensiveness - As noted earlier, SMOKE relies on user-supplied growth and control factor inputs. Therefore, the comprehensiveness of the model concerning each factor that affects future emissions levels will depend on how well the user's inputs model these factors. It should be noted, however, that SMOKE differentiates controls into three categories: multiplicative; additive; and reactivity. The multiplicative control matrix contains the combination of various types of controls typically used in emissions processing: CTG, MACT, RACT, CE, RE, RP, allowable emissions, and caps. The additive control matrix contains values which are added to the base year emissions instead of multiplying them, which is especially useful when the base year emissions are zero (for a source that comes on line between the base year and the future year). Reactivity controls model the effect of changes in the reactivity of emitted pollutants (e.g., when a solvent is changed in an industrial process). This type of control can impact speciation profiles. It is important to note that the additive control matrices do not work properly in the current version of SMOKE. Also, multiplicative controls do not work for mobile sources in the current version.

To address reactivity issues, SMOKE is able to target changes in a VOC for specific classes of VOC emissions, and address the spatial and temporal considerations implied by market penetration issues. Furthermore, when replacement of one compound in the inventory by another compound is being investigated, SMOKE facilitates the following replacement operations: selecting sources, changing underlying pollutant emissions, changing SCCs, projecting future-year emissions based in part on market penetration issues, and appropriately speciating emissions for the new compound.

Currency/ease of updates - This criterion can not be evaluated because SMOKE currently relies on user-supplied model inputs.

Flexibility - SMOKE processing is flexible because the growth and controls, chemical speciation, temporal allocation, and spatial allocation processing steps are separated into independent operations wherever possible. The results from these steps are merged together at a final stage of processing using vector-matrix mathematics. Because the processing steps in SMOKE are typically independent, a change in one of those steps does not usually require redoing the other steps. In order to generate model-input data files, however, the merge step always needs to be rerun when changes are made in other steps. One example of how this approach is beneficial is development of a control strategy. In SMOKE, changing a control

strategy requires only the control and merge steps to be processed again, whereas in other systems, most or all of the steps need to be redone.

Documentation - Partial documentation of SMOKE is currently available. Comprehensive SMOKE documentation is expected in the future. The reader can review the latest available documentation by going to MCNC-North Carolina Supercomputing Center's SMOKE web-site located at: http://envpro.ncsc.org/products/smoke/SMOKEDOCS.html.

D. SUMMARY OF EMISSION PROJECTION TOOLS

Table II-2 presents a comparison matrix overview of the emission projection tools evaluated in this chapter. This table highlights the inputs to and outputs of each projection tool and describes the hardware and software requirements for each tool. Projection tool inputs include the base year emissions, growth factors, and control factors required for each model. The "outputs" describe the geographic, pollutant, and source category scope, as well as the time-frame associated with each model. Table II-3 displays a summary of the evaluations for each tool with respect to the availability and coverage criteria.

Table II-2. Comparison Matrix of Emission Projection Models

	MODEL INPUT	MODEL OUTPUT				
MODEL (Notes)	**EMISSIONS, GROWTH FACTORS, & CONTROL FACTORS**	**GEOGRAPHY**	**POLLUTANTS**	**SOURCE CATEGORIES**	**TIME-FRAME**	**HARDWARE & SOFTWARE**
California Emission Forecasting System (CEFS) (Documentation for model is under development; CARB CEFS contact stated that it will be very difficult to research in a detailed fashion due to lengthy source code and lack of documentation)	Baseline emissions - from separate module--the California Emission Inventory Development Reporting System (CEIDARS), which is an ORACLE relational data base management system Growth factors - from separate module (Growth Module), which will contain surrogate growth data at the District/Basin/County level and can handle growth factors at the facility level. Control factors - from separate module (Rule Tracking Subsystem), which tracks controls at process level (i.e., EIC or SCC and SIC)	Projections performed in one of two independent processes: TREND forecast module - performs projections at SCC/SIC or EIC for each District/Basin/County GIS forecast module - develops gridded inventory inputs for modeling by performing projections at facility/device/process level	Total organic gases (TOG), NO_x, CO, SO_x, PM, PM_{10}, and $PM_{2.5}$. Also, reactive organic gases (ROG) and VOC are estimated as fractions of TOG; PM_{10} and $PM_{2.5}$ are estimated as fractions of PM.	All, although particular emphasis is placed on stationary sources.	Although growth factors will be available to 2030; system will be used to project only as far as 2010 due to uncertainty of control information (expectation to extend projections through 2015 in the next couple of years).	Remote on-line access; system runs on a SUN SPARC server 1000 using SunOS 5.5 UNIX operating system System is set-up for remote on-line access; both screen-based and batch file based input is permitted, with batch file input designed for use by ARB staff (district users can only make changes to their district's data)
Canada's Emission Forecasting Model (EFM) (Note that the EFM is currently in limbo due to funding constraints– requires on-going use of consultant to convert 1995 RDIS data to 1990 format used by EFM)	Baseline emissions from Canada's Residual Discharge Information System (RDIS) All other input data (e.g., growth and controls) must be developed by user; user can supply inputs as detailed as the plant ID level; can also be applied at other regional levels	National; Province/territory; and air quality management area	The 5 criteria air contaminants (i.e., VOC, NO_x, CO, SO_2, and Total PM)	All	No default input data to limit time period	IBM PC (requires FoxPro software; user-developed input files are spreadsheet-based)

Table II-2 (continued)

MODEL (Notes)	MODEL INPUT: EMISSIONS, GROWTH FACTORS, & CONTROL FACTORS	MODEL OUTPUT: GEOGRAPHY	MODEL OUTPUT: POLLUTANTS	MODEL OUTPUT: SOURCE CATEGORIES	MODEL OUTPUT: TIME-FRAME	HARDWARE & SOFTWARE
Energy 2020 (Model is custom-built for user; EPA model was never fully implemented; documentation is lacking (viewed as "black box" by one EPA user); described as "a system dynamics model," which factors in the effect of "relative prices, economic factors, budget constraint limitations, consumer preferences (non-price factors), and the nature and degree of information available")	Documentation states that data requirements are modest, that most of the data required by the model are generally available, and that model can estimate data that are not available. Standard model estimates emissions by multiplying energy demand by end-use/technology by "average pollution coefficients measured in tons per thousand Btu," which are calculated endogenously; marginal coefficients and emission standards (measured in tons per thousand Btus) must be entered by model user; the EPA's version modified standard emission factors (EPA contact was uncertain as to how factors were modified)	EPA version at State-level; vendor can develop sub-State models (cost would be about $100,000 to develop county-level model for all counties in a State)	Criteria and greenhouse gas pollutants: VOC, TSP, CO, SO2, nitrogen oxides (NO2), nitrous oxides (N20), methane (CH4), tetrafluoromethane (CF4), perfluoroethane (C2F6), sulfur hexafluoride (SF6), and hydrofluorocarbons (HFC)	All energy combustion sectors	1975-2020	EPA version was DOS-based model; current versions of Energy 2020 are developed for Windows 98/NT
Multiple Projections System (MPS) (Note that MPS was last updated in 1995 as Version 2.0)	MPS user imports 1990 base year emissions from AIRS Facility Subsystem (AFS) and Area and Mobile Subsystem (AMS) Growth factors - user imports from EGAS (user runs EGAS separately and can edit factors as appropriate) Control factors - 1990 control efficiency (CE) and rule effectiveness (RE) from AFS, 1990 rule penetration (RP) from AMS; user supplies future CE, RE, and RP	State, county, or ozone nonattainment area	VOC, NO_x, CO	All	Annual for 1990-2010	Developed for Windows 3.1; should be compatible with Windows 95/98; not compatible with Windows NT Requires 386 and 4MB RAM; hard disk requirement dependent on number and size of geographic areas included

Table II-2 (continued)

MODEL (Notes)	MODEL INPUT: EMISSIONS, GROWTH FACTORS, & CONTROL FACTORS	MODEL OUTPUT: GEOGRAPHY	MODEL OUTPUT: POLLUTANTS	MODEL OUTPUT: SOURCE CATEGORIES	MODEL OUTPUT: TIME-FRAME	HARDWARE & SOFTWARE
NONROAD Model (June 2000 draft version) Note that model also includes: Geographic allocation factors to distribute equipment populations to county level; factors based on surrogate indicators such as harvested cropland for allocating agricultural equipment Temporal allocation factors are regional. Nonroad Engine and Vehicle Emission Study (NEVES) survey data used for most of U.S., except CA allocation based on CARB's OFFROAD model	County equipment populations from National-level Power Systems Research (PSR) data (actual data for 1998, other years estimated). Other specific data sources used for population of recreational marine vehicles, snowmobiles, lawn and garden equipment, and forklifts. Engine activity (rated horsepower times load factor times annual hours used) at national level from PSR data base (exceptions are recreational marine, and lawn and garden). Engine scrappage based on normal distribution and median engine life from Environmental Energy Analysis, Inc. analysis of PSR data base. Emission factors (account for effect of Federal control programs) Growth factors - national data by fuel type (e.g., gasoline vs. diesel) calculated by extrapolating from a linear regression of PSR historical national equipment populations from 1989-1996. Exceptions include oil-field equipment (BEA projections) and airport ground support equipment (landing and take-off projections). Default data input files and packets can be revised to reflect local data that may be available to a user.	National, State, and county-level (sub-county if user provides input data).	VOC, THC, NMHC, TOG, TMOG, (exhaust and evaporative for all hydrocarbon species) NO_x, CO, CO_2, SO_2, Total PM (equivalent to PM_{10}) and $PM_{2.5}$	All nonroad sectors except commercial marine, aircraft, and locomotives	1970-2045	Windows 3.1 or Windows 95/98 486 Mhertz processor; 16 Mbytes RAM; 30 Mbytes hard disk space

Table II-2 (continued)

MODEL (Notes)	MODEL INPUT: EMISSIONS, GROWTH FACTORS, & CONTROL FACTORS	MODEL OUTPUT: GEOGRAPHY	MODEL OUTPUT: POLLUTANTS	MODEL OUTPUT: SOURCE CATEGORIES	MODEL OUTPUT: TIME-FRAME	HARDWARE & SOFTWARE
EPS 2.5 - CNTLEM is specific module in EPS that performs projections (Evaluation based on documentation for EPS 2.0; documentation has not been developed yet for EPS 2.5. Conversations with EPS developer indicate that main change from EPS 2.0 is in terms of how the model handles data arrays)	Baseline emissions - user-supplied (no default data). Growth factors - default (BEA) represents State-level data; user can apply factors as specific as the county/SCC or county/SIC levels Control factors - no default data (model is, however, designed to identify CTG and MACT applicability by emission source); user can apply factors as specific as individual sources	CNTLEM outputs total emissions for domain and total emissions by county (CNTLEM output can be allocated to grid cells of modeling domain using EPS' GRDEM module)	VOC, NO_x, CO, SO_x, TSP, and PM_{10} (VOC and NO_x are speciated in a separate EPS module)	All (model handles point sources separately from area/mobile sources)	Growth Factors limit is 2045	IBM Mainframe (can also be converted to run on UNIX platform) Requires a FORTRAN-77 compiler (requires base SAS software 6.07, SAS/AF, SAS/GRAPH, and United States map data sets to use EPS interface and emission display system).

Table II-2 (continued)

	MODEL INPUT	MODEL OUTPUT				
MODEL (Notes)	**EMISSIONS, GROWTH FACTORS, & CONTROL FACTORS**	**GEOGRAPHY**	**POLLUTANTS**	**SOURCE CATEGORIES**	**TIME-FRAME**	**HARDWARE & SOFTWARE**
Emissions Modeling System-95 (EMS-95) (EMS-95 consists of eight models, with each model having one or more modules which in turn are composed of one or more processors) Note that there are plans for a future PC version that should require a 450Mhertz Intel processor with 256 Mbytes of RAM and equivalent ultra-scsi drives as the UNIX systems (one advantage of PC version will be cost of SAS license, which should be about $5,000)	Baseline emissions - Model uses user-supplied annual-average, average-day, or day-specific emissions estimates for point and area sources and MOBILE5a emission factors and activity data for motor vehicle emissions. Growth - Model projects emissions from existing sources by applying a scaler factor. Growth factors (point source, area source, and motor vehicles) are supplied by the user. Start-ups and shut-downs are accounted for by modifying the base inventory. Growth for motor vehicles is calculated using an appropriate future year VMT file. Controls - Control factors are supplied by the user via spreadsheet or source-specific file. The model adjusts point and area source emissions by applying several control factors (e.g., CE, RE, and RP). Controls for motor vehicles are accounted for by MOBILE5a.	Projected point, area, mobile, and biogenic emissions represent gridded, hourly, pollutant-specific estimates (growth and control factors are applied after geographic and temporal allocations have taken place; speciation occurs after projection) Grid size is defined by user (grid definition file).	TOG, NO_x, SO_x, CO, PM. (For speciation, EMS-95 supports the CB-IV and SAPRAC chemical mechanisms).	All (point, area, mobile, and biogenic)	Depends on model/source providing growth and control factors.	UNIX workstation with SAS license (estimated license cost is $35,000) including SAS GRAPH and SAS FSP; SAS INSIGHT is recommended for visualization; ARC/Info license or some way to develop spatial surrogates; FORTRAN to compile MOBILE5b once 512 Mbytes RAM; 30 Gbytes of SCSI disk storage; 8mm Exabyte tape drive or DLT drive; 150Mhertz RISC CPU (not the same as 150Mhertz Intel CPU)

Table II-2 (continued)

MODEL (Notes)	MODEL INPUT: EMISSIONS, GROWTH FACTORS, & CONTROL FACTORS	MODEL OUTPUT: GEOGRAPHY	MODEL OUTPUT: POLLUTANTS	MODEL OUTPUT: SOURCE CATEGORIES	MODEL OUTPUT: TIME-FRAME	HARDWARE & SOFTWARE
Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System (Prototype and Version 1.0 are currently available) This system was developed by the Environmental Programs Group at MCNC's North Carolina Supercomputing Center (NCSC). Claims to be 35 times faster and uses 3.2 times less disk space than EMS-95, while providing more flexible input requirements, extensive documentation and support, and essentially the same processing techniques. (A current user running SMOKE for mobile sources indicates that neither the proto-type nor Version 1.0 is user friendly)	Baseline emissions - SMOKE accepts raw data in three input formats: EPS2.0 and EMS-95 formats (with some constraints and differences) and IDA (Inventory Data Analyzer) format for Models-3 (similar to the NET flat file). Control factors - the Control Model uses controls specified by the user. The **CntlmatA** program creates one or more control matrices (multiplicative, additive, projection, or reactivity) for area, mobile, or point sources, using inventory files. It uses control packets to determine which controls to apply and the values of factors for those controls. Area sources are applied by county and SCC. Point source controls can be applied at the segment level. Mobile source emission factors can be specified by State, county, road class, and link. Growth factors are user-defined and determined outside of the SMOKE model. Projection-specification files should contain both base year and target year. Although plans are to permit application of growth factors for 4-digit SIC codes, the system currently only supports SCC-based factors. SMOKE only supports State or county-level growth factors.	Processes area, point, mobile, and biogenic emissions data to create gridded, hourly emissions files by model species for air quality models. Can also produce State and county emission totals. Grid size is defined by user.	Depends on user inputs. Capable of handling all pollutants, including air toxics, with certain limitations. First, the pollutant names must be 16 characters or fewer. Second, there is a limit to the number of pollutants that SMOKE can handle in a single run. For point sources, SMOKE can handle up to 15 pollutants in a single run. For area sources, the limit is 19 pollutants and for mobile sources, the limit is 54 pollutants.	All (area, point, mobile, biogenic) Each of the major source categories requires a slightly different processing approach.	For point and area sources, time-frame depends on the model that is providing the growth and control factors. For mobile sources, time-frame is limited by MOBILE5b (currently 2050).	Currently runs on Sun workstation with SunOS 5.6; SGI workstation with IRIX 6.5, compiled for 32 or 64 bit; IBM AIX4; and developers now working on HP version. Developers also plan to have a Windows NT version by late summer 2000. Should have at least 132 Mb of memory to run SMOKE. Model is not going to run efficiently on an older workstation.

Table II-3. Summary of Availabilty and Coverage of Emission Projection Tools

EVALUATION CRITERIA		MODEL: CEFS	MODEL: Canada's EFM
Availability			
Proprietary source code	*(Yes/No)*	Yes	Yes
Licensing issues	*(Specify)*	Not applicable (model developed for specific use by CA air agencies)	Not applicable to U.S. (designed to be used with Canada's RDIS emissions inventory)
Cost	*(Amount)*	Not applicable	Not applicable
Platform:	*Intel-based/windows (Yes/No)*	No	Yes, requires FoxPro software
	Intel-based/NT (Yes/No)	No	No
	Intel-based/Linux (Yes/No)	No	No
	UNIX [Version(s)]	SUN SPARC server 1000 using SunOS 5.5 UNIX system	No
	Apple [Version(s)]	No	No
Coverage			
Categories	*Source Classification Codes (SCCs)*	All-particular emphasis on stationary sources	All
	Standard Industrial Classification (SIC) Codes (Yes/No)	Yes	Yes
	North American Industrial Classification System (Yes/No)	No	No
Pollutants	*Criteria pollutants (which ones)*	TOG, ROG, VOC, NO_x	VOC, NO_x
	Greenhouse Gases (which ones)	None	None
	Toxics (which ones)	Capable of projecting emissions for toxic pollutants, but not currently included	None
Geography	*Nation-wide (Yes/No)*	No	Yes (for Canada)
	County-level (Yes/No)	Yes	No
	Metropolitan Statistical Area (MSA) (Yes/No)	No	No
	User-specified grid (Yes/No)	Yes	No
	Other(s) (Specify)	Air basin, air district	Province/territory/air quality management area
Time Periods	*Annual, Seasonal, Monthly, Daily, Hourly*	Annual, seasonal, daily, hourly	Annual
	Historical Period (Back to?)	Back through 1970	No default input data to limit time period
	Forecast Period (To?)	Capability through 2030; control factors currently limit projections to 2010	No default input data to limit time period

Table II-3 (continued)

EVALUATION CRITERIA		MODEL		
		ENERGY 2020	**MPS**	**NONROAD**
Availability				
Proprietary source code	*(Yes/No)*	Yes	No	No
Licensing issues	*(Specify)*	License allows user to distribute model freely to others for "review and critique"	None	None
Cost	*(Amount)*	$100,000 "ballpark" estimate for a county-level model for one state	None	None
Platform:	*Intel-based/windows (Yes/No)*	Yes	Yes	Yes
	Intel-based/NT (Yes/No)	Yes	No	No
	Intel-based/Linux (Yes/No)	No	No	No
	UNIX [Version(s)]	No	No	No
	Apple [Version(s)]	No	No	No
Coverage				
Categories	*Source Classification Codes (SCCs)*	All energy sectors, but does not use SCC system	All	All nonroad except commercial marine, aircraft, locomotives
	Standard Industrial Classification (SIC) Codes (Yes/No)	Yes	Can carry SIC codes, but can't be used to apply growth or control factors	No
	North American Industrial Classification System (Yes/No)	No	No	No
Pollutants	*Criteria pollutants (which ones)*	VOC, CO, SO_2	VOC, NO_x	VOC (& THC, NMHC, TOG, TMOG), NO_x
	Greenhouse Gases (which ones)	CO_2	None	CO_2
	Toxics (which ones)	None	None	None
Geography	*Nation-wide (Yes/No)*	Yes (when specified by user)	Yes	Yes
	County-level (Yes/No)	Yes (when specified by user)	Yes	Yes
	Metropolitan Statistical Area (MSA) (Yes/No)	Yes (when specified by user)	No	No
	User-specified grid (Yes/No)	No	No	No
	Other(s) (Specify)	State, utility service area	State, ozone nonattainment area	State, sub-county (if user provides input data)
Time Periods	*Annual, Seasonal, Monthly, Daily, Hourly*	Annual	Annual, seasonal, monthly, daily	Annual, seasonal, monthly, daily
	Historical Period (Back to?)	1975	1990	1970
	Forecast Period (To?)	2020	2010	2045

Table II-3 (continued)

EVALUATION CRITERIA		MODEL		
		EPS 2.5	EMS-95	SMOKE
Availability				
Proprietary source code	*(Yes/No)*	No	No	No
Licensing issues	*(Specify)*	Requires FORTRAN-77 compiler (and SAS software to use interface & display system)	Requires SAS software including SAS GRAPH, SAS FSP, and SAS INSIGHT	None, but MCNC does not provide SMOKE support to the general public
Cost	*(Amount)*	None except for cost of FORTRAN compiler	Free, but SAS software is estimated to cost $35,000	Free
Platform:	*Intel-based/windows (Yes/No)*	No	No	No
	Intel-based/NT (Yes/No)	No	No, but future plans for NT version	No
	Intel-based/Linux (Yes/No)	No	No	No
	UNIX [Version(s)]	IBM mainframe model that can be converted to run on UNIX	Sun workstation	Sun workstation with SunOS 5.6, SGI workstation with IRIX 6.5, and IBM AIX4
	Apple [Version(s)]	No	No	No
Coverage				
Categories	*Source Classification Codes (SCCs)*	All	All	All
	Standard Industrial Classification (SIC) Codes (Yes/No)	Yes	Yes	Yes, but does not currently support SIC growth factors
	North American Industrial Classification System (Yes/No)	No	No	No
Pollutants	*Criteria pollutants (which ones)*	VOC, NO_x	NO_x	Handles all user-supplied pollutants.
	Greenhouse Gases (which ones)	No	None	Handles all user-supplied pollutants.
	Toxics (which ones)	No	None	Handles all user-supplied pollutants.
Geography	*Nation-wide (Yes/No)*	No	No	No
	County-level (Yes/No)	Yes	No	Yes
	Metropolitan Statistical Area (MSA) (Yes/No)	No	No	No
	User-specified grid (Yes/No)	Yes	Yes	Yes
	Other(s) (Specify)			State
Time Periods	*Annual, Seasonal, Monthly, Daily, Hourly*	Annual, seasonal, daily, hourly	Hourly	Annual, monthly, daily, hourly
	Historical Period (Back to?)	Depends on user-supplied control factors; default growth factors through 2045	Depends on period in user supplied information	Depends on period in user supplied information
	Forecast Period (To?)	Depends on user-supplied control factors; default growth factors through 2045	Depends on period in user supplied information	Depends on period in user supplied information

SECTION III
SURROGATE EMISSIONS GROWTH DATA

A. INTRODUCTION

In some cases, emission projections models provide default emissions growth data (e.g., the NONROAD model), while in other cases, the user is expected to supply these data (e.g., EMS-95). Emission projections can be developed using the emission projections models described in Section II or simply by applying the appropriate procedures (Volume X, "Emissions Projections," of the EIIP Technical Report Series describes appropriate projection procedures). The purpose of this section is to identify and describe various sources of emissions growth surrogate data for use as inputs to preparing emission projections.

One of the primary sources of emissions growth surrogate data is the EPA's EGAS, which was last released as Version 3.0 in 1995. The same year, BEA published their final set of regional economic projections. Since then, the EPA has employed both EGAS and BEA forecast data in projecting emission inventories for various Agency projects. Given the dynamic nature of the United States economy, the validity of these 1995-based forecast data for projecting emissions becomes more questionable with each passing year. There are no plans for future updates to the BEA forecast data, however, the EPA has recently funded the development of an updated version of EGAS. This section will present information on the forecast data included in the forthcoming EGAS Version 4.0 and discuss alternative emissions growth surrogate data sources.

The primary focus of the alternative emissions growth surrogate data review was to identify product output-based forecast data. As noted in EPA's Projections Guidance document, product output is the preferred indicator of emissions growth. EGAS produces growth factors for most source categories based on forecasts of constant dollar sales for each of 168 economic sectors, which are generally equivalent to the 3-digit SIC code level. Product output forecast data, such as the amount of solvent used in automobile refinishing, provides a more specific measure of the future level of emissions activity than economic output data (e.g., sales in the Automobile Parking, Repair, and Services sector).

In addition to investigations into product output forecast data, research was conducted into whether more specific economic output forecast data may be available. Specifically, Pechan investigated the availability of more detailed information with regard to geographic scope, forecast period, and industries covered (e.g., 4-digit SIC code). The identification of more specific sources of emissions activity growth data could provide information for potential improvements to EGAS and could assist State and local agencies that may want to consider alternatives to EGAS forecast data.

The remainder of this section is organized as follows. A discussion of the forthcoming EGAS Version 4.0 is provided next in Section B. This discussion highlights the history behind the development of EGAS 4.0, and describes the system's geographic scope, time horizon, and forecast data sources. Sections C through F present information on forecast data available from economic forecasting firms. The following companies were contacted in this review:

- McGraw-Hill Companies' DRI and F.W. Dodge;
- RFA (formerly known as Regional Financial Associates); and
- Wharton Econometrics Forecasting Associates (WEFA).

The information obtained from each of these economic forecasting firms is organized into two major sections: (1) Potential Improvements to EGAS 4.0 Data; and (2) Options for Obtaining Forecast Data. Section G presents information on forecast data available from the following market research firms:

- Business Communications Company, Inc.;
- The Freedonia Group, Inc.;
- Frost and Sullivan;
- Kalorama Information LLC; and
- SRI Consulting.

This section first provides an overview of the types of forecast data that each firm provides, then presents a list of market research reports produced by these firms with applicability for emissions forecasting, and concludes with comparisons of EGAS 4.0-based emission growth factors with emission growth factors computed from the Freedonia Group, Inc. These comparisons were developed based on the availability of market research forecast data for the top 50 VOC-emitting source categories and the top 25 $PM_{2.5}$ and NO_x-emitting source categories as identified from EPA's NET inventory.

B. EGAS

1. Overview

EGAS is an emissions activity forecast model that provides State and local governments with an EPA-approved set of emissions activity growth factors. EGAS was first released in 1992 and was last updated as Version 3.0 in 1995.[2] Since 1998, EPA has been working to update EGAS to:

[2] Young, T. and Capone, R. "Economic Growth Analysis System: Version 3.0 Reference Manual, Final Report," EPA-600/R-95-132a. Prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, by TRC Environmental Corporation, Chapel Hill, NC, and Ronald L. Capone & Associates, Staunton, VA. August 1995.

- Incorporate an updated set of forecast data from REMI and an updated set of WEFA macroeconomic projections;[3]

- Include more than 2,600 additional SCCs and review the assignment of all Version 3.0 growth indicators to SCCs and SIC codes, in part, to account for a reduction in sector detail available from REMI's models (from 210 sectors for the models in Version 3.0 to 172 sectors for the models in Version 4.0);

- Include three new North Carolina modeling areas;

- Incorporate updated energy demand models/forecasts based on an analysis of alternatives for updating the residential, commercial, industrial, and electric generation energy demand models included in EGAS Version 3.0;

- Integrate updated VMT forecasts based on the availability of updated historical VMT data;

- Incorporate a new set of regression equations for large emission source categories that relate historical emissions activity data to historical REMI output data;

- Include nonroad emission source category growth indicators from the EPA's draft NONROAD emissions model; and

- Run in a Windows 95/98 environment.

In addition, EPA updated the BEAFAC utility by developing growth factors based on BEA forecasts of constant dollar GSP by industry and reviewing and updating the assignment of BEA industry sectors with SCCs and SIC codes. Information on EGAS is maintained in the "Projections" section of EPA's Clearinghouse for Inventories and Emissions Factors (CHIEF) web-site, which is located at http://www.epa.gov/ttn/chief/emch/projection/index.html.

2. EGAS 4.0 Data Sources

The emission growth surrogate data in the forthcoming EGAS 4.0 derives from REMI industry-specific output (sales) data, the EPA's NONROAD model, EPA VMT forecasts, and DOE energy demand models.[4] For most SCCs and 2-digit SIC codes, EGAS develops area-specific emission growth factors based on projected real output (i.e., constant dollar sales) for each of 172 economic sectors included in REMI area-specific economic models. These growth

[3] WEFA projections are used as an alternative set of final demand drivers to REMI's regional economic models.

[4] EGAS also includes a separate utility, BEAFAC, which uses economic projections from the BEA to develop emission growth factors by 2-digit SIC code or SCC. The BEA last developed economic forecasts in 1995 and has no plans to update these projections in the future.

factors are then applied to each county in a modeled area; EGAS 4.0 contains 75 modeling areas. The following sections describe the REMI and other forecast data sources in more detail.

a. REMI

A major component of the EGAS system is the REMI Economic Demographic Forecasting System (EDFS)-14 economic model. The REMI economic model forecasts regional economic growth based on a consistent set of National growth assumptions. In the REMI models, regional growth is affected by a number of factors, including the performance of the National economy and the relative costs of doing business in each modeled region. The relative costs of doing business are determined endogenously. The growth or decline of the National economy, however, is determined outside of the regional models. For EGAS, users can select REMI economic projections based off of either the Bureau of Labor Statistics National projections, which is the default, or the WEFA projections. As part of the EGAS 4.0 update, EPA procured an updated set of WEFA macroeconomic forecast data for use as an alternative set of final demand drivers for REMI's economic models.

For certain source categories, EPA adjusted the REMI output data based on the historical relationship between output for a specific economic sector and emissions activity. In particular, EPA compiled a list of the top emitting source categories across all criteria air pollutants based on the 1996 NET inventory. The EPA then compared this list to a list of source categories for which long-term emissions activity data were available from past NET inventory development efforts. For source categories where emissions activity data were readily available, EPA developed regressions of the emissions activity data with REMI sector output to identify coefficients for adjusting REMI output forecasts to account for the historical relationship between REMI sector output and source category emissions activity. The results of these regression analyses replaced the regression coefficients that were included in EGAS 3.0.

Due to resource constraints, EPA was forced to eliminate the simulation forecast capabilities that were included in EGAS Version 3.0. The simulation forecast provided EGAS users with the option of changing "policy variable" values to simulate the impact of policy changes, such as tax increases, on the REMI regional economic forecasts. Information on REMI's models is available from REMI's web-site located at http://www.remi.com.

b. DOE's *Annual Energy Outlook*

For emission sectors with energy consumption data for emissions activity, EGAS Version 4.0 develops growth factors using energy demand forecast data from the DOE's *Annual Energy Outlook*. This approach generally applies Census division-level energy forecasts from the DOE across the EGAS modeling areas that approximate each Census division. The DOE data are fuel and sector-specific (e.g., natural gas consumption in the residential sector) and are available on an annual basis through the year 2020. To incorporate the DOE data into EGAS 4.0, EPA developed a list of SCCs whose emissions activity is a function of the amount of fuel consumed. Next, EPA linked these SCCs to the best available indicator from the DOE's *Annual Energy Outlook*. For fuel types where Census division-level forecast data were available, EPA used these data as the surrogate growth indicators; in cases where a fuel type was only available at the

National level, or when DOE provided sector-specific fuel combustion data (e.g., distillate fuel consumption in the chemicals industry), EPA employed National DOE data. Additional information on the DOE's *Annual Energy Outlook* is available from the following web address: http://www.eia.doe.gov/oiaf/aeo/index.html.

c. EPA's NONROAD Model

The EPA's NONROAD model includes the following nonroad equipment categories: agricultural; airport support; light commercial; construction and mining; industrial; lawn and garden; logging; pleasure craft; railroad; and recreational. Aircraft, locomotives, and commercial marine categories are not included in the NONROAD model. To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by appropriate emission factors. Geographic allocation factors are used to distribute National equipment populations to counties. These factors are based on surrogate indicators such as harvested cropland for allocating agricultural equipment. The engine activity data (i.e., load factor times annual hours of use) included in NONROAD are National averages. For most categories, the activity data are derived from a Power Systems Research data base, although exceptions include recreational marine and lawn and garden activity.

The EPA has developed growth indicators as one of the inputs to the draft NONROAD model. These growth indicators, which are National, relate solely to the forecasted population of nonroad engines (i.e., the NONROAD model does not project changes in hours of use or engine load factor). These growth indicators are based on the average growth rate for engine applications by fuel type (e.g., 2-stroke gasoline recreational vehicle engines) and are applied to NONROAD model source categories at the 7-digit SCC-level. For EGAS Version 4.0, EPA developed National-level growth factors from the NONROAD model data, and assigned these growth factors to nonroad SCCs in EGAS based on their 7-digit SCC. It is important to note that the NONROAD model is an emissions estimation model, and, as such, includes additional concepts (e.g., equipment scrappage) that are not incorporated into EGAS Version 4.0. Section II.C.e. provides further details on EPA's NONROAD emissions model.

d. VMT Data

EGAS Version 3.0 includes two methods for projecting VMT: (1) linear regression of Highway Performance Monitoring System (HPMS) historical VMT data; and (2) allocation of National VMT projections from EPA's MOBILE4.1 Highway Fuel Consumption Model (HFCM) to EGAS areas based on relative population growth. The first method was used to project VMT for a 6-year period; projections after this period were determined using the National VMT allocation procedure. These approaches were carried-over into EGAS 4.0. However, EPA developed a new set of VMT regressions based on an updated set of HPMS VMT data, and incorporated a new set of REMI population growth forecasts for use in the VMT allocation procedure. It is important to note that EGAS develops projections of total VMT, which is then applied to all VMT source categories (i.e., light-duty gasoline vehicle VMT is grown at the same rate as heavy-duty diesel truck VMT).

e. BEA

The BEA's final set of projections data was released in 1995. The previous set of BEA projections, released in 1992, contained forecast data for 1995, 2000, 2005, 2010, 2020, and 2040. As part of the BEAFAC utility, EGAS Version 3.0 provided growth factors for 1991-2015 developed from BEA's earnings projections by industry sector. The final set of BEA projections are available for the years 1998, 2000, 2005, 2010, 2015, 2025, and 2045. In addition to the earnings data provided in the previous set of BEA projections, this final projections series includes GSP projections by industry and State. For the EGAS Version 4.0 update, area and point source growth factors were developed for 1997-2020 based on linear interpolation of the 1995 BEA GSP data. The GSP data were incorporated because the updated earnings projections are only available at the 1-digit SIC code level, whereas the GSP projections are available at the 2- and 3-digit SIC code level. It should also be noted that EPA projections guidance states that value added (GSP) data are preferred over earnings data in projecting emissions. As part of the update to BEAFAC, EPA included BEA industry matches to the additional 2,600 SCCs in EGAS Version 4.0 and reviewed and updated the BEA industry to SCC matches from EGAS Version 3.0. It is important to note that the BEA released their last set of regional projections in 1995 and that there are no plans for future updates.

C. DRI

DRI, the research services division of Standard and Poors', provides forecasting and economic analyses of both national and international markets. Standard and Poors' is the financial services arm of the McGraw-Hill Companies, which owns numerous information and media services businesses. Given McGraw-Hill's extensive array of information products, DRI is able to draw on the expertise of the various McGraw-Hill businesses in developing its data bases and forecasts. The DRI web-site at http://www.dri.standardandpoors.com can be reviewed for information on DRI's regional forecasting services.

1. Potential Improvements to EGAS 4.0 Data

The following sections describe DRI forecasts that provide potential improvements to the projections data included in EGAS 4.0.

a. Product Output Data

Like REMI, DRI generally does not develop product output forecasts. However, DRI develops energy forecasts on a regional basis. Given the availability of free DOE projections on a similar geographic basis, EPA did not examine DRI's energy forecasts.

b. Other Data

DRI regularly develops State- and MSA-level employment and dollar output projections for 239 industry sectors, which cover a mix of 2-, 3-, and 4-digit SIC code industries. DRI's 239 industry forecasts provide approximately 65 additional sectors compared to the REMI models included in EGAS Version 4.0. Table A-1 lists each of the 254 National DRI sectors with their

associated SIC codes, and identifies the 239 DRI sectors available at a sub-National level. Examples of the additional regional sectoral detail provided by DRI are the following:

- Construction and Related Machinery (SIC code 353) is disaggregated into Construction Machinery (SIC code 3531); Mining and Oil Field Machinery (SIC codes 3532-3); Elevators and Materials Handling Equipment (SIC codes 3534-6); and Industrial Trucks and Tractors (SIC code 3537);

- Engines and Turbines (SIC code 351) is disaggregated into Turbines and Turbine Generator Sets (SIC code 3511); and Internal Combustion Engines, not elsewhere classified (SIC code 3519); and

- Primary Nonferrous Smelting and Refining (SIC code 333) is disaggregated into Copper (SIC codes 3331, part of 3341, 3351); Aluminum (SIC codes 3334, part of 3341, 3353-5, 3363, and 3365); and Nonferrous Metals, not elsewhere classified (SIC codes 3339, part of 3341).

Although their regular county-level employment and output projections are too aggregated for use in emissions forecasting, DRI notes that they can develop county-level forecasts at a 239 sector level as part of a custom forecast effort.

2. Obtaining DRI Forecast Data

DRI's information is available from a variety of services, so a client may choose an all-encompassing product or a more specific service. DRI's MarketScan, which is a product of their U.S. Industry Service, provides 254-sector National-level output and employment forecasts for a 10-year period. DRI's U.S. Regional Service has 239 sector employment and real dollar output for each State and for 319 metropolitan areas for a 25-year time horizon. DRI can provide forecasts to suit an individual client's specifications. For example, clients can purchase forecasts for individual States, groupings of States, or all 50 States and the District of Columbia. The most cost-effective way to purchase DRI forecast data, DRIQuest, provides access to DRI's most detailed regional data. DRIQuest is a Windows-based software application containing a database and report writer that allows users to retrieve and analyze DRI's data short- and long-term forecasts. The annual subscription fee for a single user of this service is $9,270; a site license is $18,000. DRI also provides other regional economic services, including a State Economic Package that costs $9,000 for one State and $2,000 for each additional State, up to a maximum of $27,000. This service provides comprehensive coverage of the economic activity within a single State (or a set of States) and every metro area, county, and industry in that State (or set of States). In addition to DRIQuest access to data for their subscribed State(s), this service provides clients with every published article that DRI produces concerning their State and metro area economy. The DRI web-site at http://www.dri.standardandpoors.com can be reviewed for information on additional DRI regional economy publications.

Although DRI does not regularly produce county-level output and employment forecasts at the 239-sector level, DRI has quoted a price of $10,000 for this custom forecast service. To

develop these forecasts, DRI would link their national input-output model to their dynamic regional economic models.

D. F.W. DODGE

F.W. Dodge, which is also owned by McGraw-Hill, is a leading provider of information products covering the construction market. For example, F.W. Dodge provides construction forecasts and trends analyses for both residential and nonresidential construction markets. As such, F.W. Dodge forecasts could be used as surrogate growth indicators for such diverse source categories as road construction (forecasts of dollars of street and highway construction) and commercial fuel combustion (forecasts of commercial square footage).

1. Potential Improvements to EGAS 4.0 Data

a. Product Output Data

F.W. Dodge's short-term construction forecasts contain 5-year projections that are developed on a quarterly basis, and its long-term forecasts extend 25 years into the future. Forecasts are available for every County, Metropolitan Area, State, and Region for the project types listed in Table III-1. F.W. Dodge forecasts are provided by contract value, square footage, and number of units. F.W. Dodge also develops building product demand (e.g., bathtubs) forecasts.

Table III-1. F.W. Dodge Construction Project Types

Nonresidential	Nonbuilding	Residential
Stores	Streets and Highways	Single-Family
Commercial Warehouses	Bridges	Two-Family
Offices	Dams and Reservoirs	Multi-Family
Parking Garages/Service Stations	Sewers and Waste Disposal	
Manufacturing	Water Supply Systems	
Education	Power/Communication	
Health	Other Nonbuilding	
Public		
Religious		
Amusement		
Misc. Nonresidential		
Hotels		
Dormitories		

b. Other Data

F.W. Dodge does not develop economic output or employment forecasts. However, State and local agencies that are interested in short-term construction projections should investigate the *Dodge Pipeline* data base. This Microsoft Access data base contains information on commercial construction projects values at $1 million or more that are in the construction "pipeline." This data base provides eight quarters of information based on real construction plans. Data are available for the top 110 metropolitan areas for five project types and can be queried at the MSA, county, city, or zip code levels. Square footage and number of units data are available by project phase for each of five building types. Additional information is available at http://www.mag.fwdodge.com/realestate/aboutpip.htm.

2. Obtaining F.W. Dodge Forecast Data

Pechan asked F.W. Dodge for a price quote for the following construction data identified as most relevant to emissions activities:

- Total Non-Residential construction (square footage and dollar value);
- Manufacturing construction (square footage and dollar value);
- Streets and Highways construction (dollar value); and
- Single-Family, Two-Family, and Multi-Family residential construction (number of units and dollar value).

To purchase a one-time forecast of 25-year State-level data for the above construction variables, F.W. Dodge quotes a price of $27,700; for a one-time forecast of 25-year State- and county-level data, F.W. Dodge quotes a price of $32,211. The F.W. Dodge web page, http://www.mag.fwdodge.com/, contains information on alternative ways to procure F.W. Dodge forecast data.

E. RFA (ECONOMY.COM)[5]

RFA provides economic research, forecasting, and consulting services that extend to the macroeconomy, financial markets, industrial markets, and regional markets (i.e, States, MSAs, and Counties). RFA develops unique large-scale, simultaneous-equation econometric models that differ from many other forecasting companies by incorporating both top-down and bottom-up components. Model variables such as interest rates, prices, and business investment are modeled as national variables, whereas sectors such as labor markets, demographics, and construction activity are modeled regionally and then aggregated to national totals.

1. Potential Improvements to EGAS 4.0 Data

The following sections describe RFA forecast data that may provide better alternatives to the forecast data currently offered by EGAS Version 4.0.

[5] RFA, formerly known as Regional Financial Associates, changed its name to Economy.com, Inc. as of July 2000. Economy.com, Inc. is referred to as RFA in this report.

a. Product Output Data

As with the REMI data included in EGAS, most of RFA's economic forecasts are based on dollar value of output terms rather than production output terms. RFA production forecasts are generally available only at the National level. Table III-2 displays a list of production-oriented forecast data that provide relevant information for forecasting emissions activities. For example, the projected number of traffic accidents may be a more specific indicator of the future level of automobile refinishing activity than the EGAS 4.0 indicator – projected constant dollar sales in the Automobile Parking, Repair, and Services sector. For each RFA forecast variable, Table III-2 presents a sample source category to which the variable is related, as well as the time period and most detailed geographic level for which forecast data are available. In cases where county-level is the most detailed geographic scope listed, more aggregate data are generally also available. For example, single- and multi-family housing permit forecasts are available at the MSA, State, and National levels as well as the county-level. Unlike the 20-year time-frame available for other geographic levels, the Metropolitan Area forecasts are developed for a 10-year period (however, RFA has stated that these can be extended to a 20-year period). It is important to note that the source category applicability in Table III-2 for each variable is not comprehensive. For example, Production – Oil, Gasoline, Distillate Fuel, Residual Fuel, and Jet Fuel could also serve as a surrogate indicator for Petroleum Product Storage Tank emissions activity.

RFA forecast data bases fall into three major categories, *core, specialized*, and *industry*. Variables available from RFA's *core* forecast and *industry* data bases that are not provided in EGAS Version 4.0 are described below; discussion of RFA's *specialized* forecasts is provided in the following section. RFA *core* forecast services are organized by geographic scope (i.e., Macro, State, Metro, and County).

RFA's *U.S. Macro* service provides National forecasts of: car sales; light-truck sales; single-family housing starts; multi-family housing starts; new single-family home sales; office employment; industrial sector employment; commercial sector employment; 2-digit SIC code industrial production indices; number of households; and value of construction put in place for office, industrial, commercial, and other nonresidential construction. The RFA's *U.S. State* service forecast includes: number of households; number of housing permits (both single-family and multifamily); existing home sales; and new vehicle registrations (car and light truck). The *U.S. Metro* service forecast includes: number of households; number of housing permits (single-family, multi-family, and five-plus units); and existing home sales. The *U.S. County* service forecast provides: number of households; number of housing permits (both single-family and multi-family); existing home sales; single- and multi-family housing starts, single-family housing stock; multi-family housing stock; and office employment.

The RFA's *industry* data base service and associated *Precis: Industry* publications provide National forecasts for approximately 60 industries and cover several variables of interest for emissions forecasting, including: steel production; passenger tire shipments; crushed stone production; and natural gas production. These forecasts however only have a 5-year time horizon. Of the four RFA *Precis: Industry* publications, the "Manufacturing" and the "Commodities, Energy, and Transportation" publications provide the majority of potential RFA surrogate emissions activity data.

Table III-2. Physical Output-Related Forecast Data Available from RFA

RFA Data (*Information Source*)	Sample Source Category Applicability	Time Period	Most Detailed Geog. Scope
Traffic Accidents (*Industry: Auto Parts Manufacturing*)	Automotive Refinishing	5-year	U.S.
Cement Shipments (tons) (*Industry: Cement & Aggregates*)	Cement Manufacturing	5-year	National & Northeast South Midwest West
Nonutility Net Electricity Generation (kWh) (*Industry: Electric Utilities*)	Cogeneration	5-year	U.S.
Airline Revenue Passenger Miles, Domestic (*Industry: Oil & Gas Refining & Marketing*)	Commercial Aircraft	5-year	U.S.
Office Employment (*County Core Forecast*)	Commercial Fuel Combustion	20-year	County
Nonresidential Construction Put in Place (in 1992 $) - Total; Office; Industrial; Commercial; Other (*U.S. Macro Core* and *RFA Data Buffet* Ch. 4)	Construction	5-year	U.S.
Construction Put in Place (in 1992 $): Residential Improvement and Repair (*Industry: Industrial Machinery*)	Construction	5-year	U.S.
Housing Permits: Single Family; Multi-family (*County Core Forecast*)	Construction	20-year	County
Housing Starts: Single Family; Multi-family (*County Core Forecast*)	Construction	20-year	County
Copper, Production (tons)- Mined; Refined; Scrap (*Industry: Copper*)	Copper Production	5-year	U.S.
Electricity Consumption (kWh) - Residential; Commercial, Industrial (*Industry: Electric Utilities*)	Electric Generation	5-year	U.S.
Consumption - Gasoline (bbls/day); Distillate Fuel; Residual Fuel; Jet Fuel (*Industry: Oil & Gas Refining & Marketing*)	Fuel Combustion	5-year	U.S.
Industrial Production Index (% change): For most Mining and Manufacturing 2-digit SIC codes (*U.S. Macro Core*)	Industrial Processes (various)	20-year	U.S.
Municipal Solid Waste - Total; Per Person Per Day (*Industry: Environmental. Services*)	Municipal Landfills	5-year	U.S.
Consumption - Natural Gas (ft^3) (*Industry: Oilfield Services & Production*)	Natural Gas Combustion	5-year	U.S.
Natural Gas Consumption (ft^3)- Residential; Commercial; Industrial; Electric Utility; Lease & Plant Fuel (*Industry: Natural Gas*)	Natural Gas Combustion	5-year	U.S.
Total Dry Gas Production (ft^3) - Natural Gas (*Industry: Oilfield Services & Production*)	Natural Gas Production	5-year	U.S.

Table III-2 (continued)

RFA Data (*Information Source*)	Sample Source Category Applicability	Time Period	Most Detailed Geog. Scope
Stock of Cars and Trucks (*Industry: Tires & Rubber*)	Paved Roads, Fugitive Dust (combine w/ Lane Road Miles)	5-year	U.S.
Vehicle Registrations: Cars; Light Trucks (*State Core Forecast*)	Paved Roads, Fugitive Dust (combine w/ Lane Road Miles)	20-year	State
Miles Traveled per Automobile (*Industry: Oil & Gas Refining & Marketing*)	Paved Roads, Fugitive Dust (when combined with Vehicle Count)	5-year	U.S.
Production - Oil (bbls/day); Gasoline; Distillate Fuel; Residual Fuel; Jet Fuel *(Industry: Oilfield Services & Production*)	Petroleum Refining	5-year	U.S.
Natural Gas Pipeline Mileage (*Industry: Natural Gas*)	Pipeline Valve Leaks	5-year	U.S.
Railroads: Coal Carloads; Chemical Carloads; Grain Carloads (*Industry: Railroads*)	Rail Car Transport	5-year	U.S.
Railroads: Revenue Ton-Miles of Rail Freight (*Industry: Railroads*)	Railroad Fuel Combustion	5-year	U.S.
Housing Stock: Single Family; Multi-family (*County Core Forecast*)	Residential Fuel Combustion	20-year	County
Households (*County Core Forecast*)	Residential Fuel Combustion	20-year	County
New Single-Family Home Sales (*U.S. Macro Core Forecast*)	Residential Lawn and Garden Equipment	20-year	U.S.
Highway Lane Miles (*Industry: Cement & Aggregates*)	Road Construction	5-year	U.S.
Sand and Gravel Production in (tons) (*Industry: Cement & Aggregates*)	Sand & Gravel Production	5-year	U.S.
Semiconductor Equipment Sales ($) - U.S. Makers (*Industry: Semiconductors & Equipment*)	Semiconductor Manufacturing	5-year	U.S.
U.S. Steel, Production and Apparent Consumption (tons) (*Industry: Steel*)	Steel Production	5-year	U.S.
Crushed Stone Production in (tons) (*Industry: Cement & Aggregates*)	Stone Quarrying	5-year	U.S.
Tire Shipments - Passenger; Light Truck; Other Truck (*Industry: Tires & Rubber*)	Tire Manufacturing	5-year	U.S.
Sales - Total Light Vehicle; Car; Light Truck (*U.S. Macro Core Forecast*)	Vehicle Production	20-year	U.S.

b. Other Data

RFA's specialized data bases cover concept specific coverage (employment, output, occupations) and include the following: Detailed Employment & Output (States and Metropolitan Areas); Detailed Employment & Output (Counties); and Occupational Employment and Wages (States and Metropolitan Areas). The detailed employment and dollar output data bases provide forecasts at the 2- and 3-digit SIC code level for a 20-year period. The occupational employment and wages data base, which is available for States and MSAs, contain 10-year forecasts for 120 different occupations. These forecasts are also available by 3-digit SIC code. Purchase of this data base also provides users with a subscription to the Detailed Employment & Output data base for States and Metropolitan Areas.

In addition to RFA's core and specialized data bases, RFA's *Industry* data base provides National-level 20-year employment, output, and average wage/average number of employees data at the 1-, 2-, 3-, and 4-digit SIC-code level. County-level coverage is also provided at the 1-, 2-, or 3-digit SIC code level, depending on the sector. Purchase of this data base also provides users with access to the employment and output 3-digit SIC code county forecasts at no additional cost.

RFA can also provide the following projections data, upon demand, for any State, MSA or county at the 2-, 3-, or 4-digit SIC code level:

- Payroll employment;
- Real and nominal output;
- Wage and salary compensation;
- Establishments counts, which provide net business information and average business employment size; and
- Payroll employment and establishment counts by employee size class for 2-, 3-, and 4-digit SIC code. Nine class sizes are available, ranging from 0-4 employees to more than 1,000 employees. (Net business formations and employment growth are divided between small and large establishments.)

The following section describes the cost to obtain these data and the other RFA forecast data described above.

2. Obtaining RFA Forecast Data

RFA provides numerous ways to access their forecast data, including the following:

- A subscription service that provides monthly forecast updates and analysis of all States, MSAs, and Industries;
- Unlimited access to RFA's core, specialized and industry forecast data bases;

- Individual RFA National, State, MSA, and industry "*Precis*" reports (e.g., *Precis: State Edition*), which contain 5 years of forecast data; and

- Customized forecast reports based on the forecast variable and update frequency required by the client.

As mentioned earlier, there are three RFA data base categories of interest to the committee: the core forecast, the specialized forecast, and the industry forecast. The core forecast data bases include the following: U.S. Macro Forecast ($3,500); State Forecast (individual State is $3,500; 50-State is $7,500); Metropolitan Area Forecast ($12,500); and County Forecast ($25,000, which includes access to the core Metropolitan Area Forecast data base). The specialized concept data bases may be purchased for one year at a cost of $7,500 for the State- and MSA-level detailed employment and output forecasts, $11,250 for the State- and MSA-level detailed occupation, wage, employment, and output forecasts; and $10,000 for the county-level detailed employment and output forecasts. The RFA's *Industry* data base may be purchased along with all editions of the *Precis: Industry* publication for approximately $8,500 per year. The individual Industry publications ("Natural Resources/ Transportation," "Consumer/Health Services," "Financial/Business Services," and "Manufacturing") may be purchased for $3,495 per year.

RFA also packages some of the detailed employment and occupation forecast tables in RFA's data bases for a less expensive price. The employment tables contain 2-digit employment forecast data for all 50 States and for metropolitan areas. These tables contain 10 years of employment forecasts for the major 2-digit SIC codes. These tables, which are updated monthly, may be purchased for individual metropolitan areas or States for $200. The occupation forecast tables cover 100 occupations for 315 metropolitan areas and all 50 States. The occupation forecast tables include 6 years of history and 5-year forecasts, and may also be purchased by area for $200. The occupation tables are updated on a quarterly basis.

RFA forecast data can also be accessed through custom-designed State or metropolitan area regional reports. RFA reports may be customized many ways to emphasize regions and/or sectors of interest (employment, output, housing, etc.). This option can provide a significant advantage over the mass-produced regional forecasts of WEFA and DRI in that RFA offers each client the flexibility to design its own regional products. Specifically, a client can select the variables they want forecasted, along with the level of forecast detail and the medium in which it will be delivered. RFA also allows clients the option of using RFA's macro forecast to drive the regional forecast or the client's own forecast. RFA also allows clients the ability to determine the update frequency of their forecasts (e.g., once per year, four times per year, etc).

As noted in the previous section, RFA can also produce on demand a set of 4-digit SIC code employment and output projections at the State, MSA, or county level. For an individual State, MSA, or county, the price for someone that subscribes to RFA's specialized forecast data base is $200 for employment and $400 for output and or establishment counts. These prices double if someone does not subscribe to the specialized forecast data base. Multiple States, MSAs, or counties can also be purchased; RFA develops specific price quotes for this service. Additional information on RFA's services is available from RFA's web-site located at http://www.rfa.com.

F. WEFA

WEFA, Inc. specializes in developing U.S. historical and forecast economic time series data. In addition to making its time-series information available through a variety of services, WEFA also performs customized economic modeling for clients. In general, WEFA conducts its economic analysis at the National, State, and MSA levels, with certain economic indicators only available at the National and State level.

1. Potential Improvements to EGAS 4.0 Data

The following sections highlight WEFA forecast data with potential to improve upon the forecast data available from EGAS 4.0.

a. Product Output Data

WEFA provides product-based forecast data that are not available from EGAS. Specific sectors for which WEFA develops production forecasts are:

- Crops (covering specific field and row, fruits and nuts, and vegetable crops);
- Livestock (covering specific bovine, swine, poultry, and dairy animal categories);
- Fertilizer (covering primary fertilizer nutrients);
- Automotive (covering automobiles, trucks, and truck trailers);
- Railroads (covering rail freight cars); and
- Steel (covering steel production by process).

WEFA's agriculture data bases provide county level forecasts of acreage planted or harvested for 56 crops and State level forecasts of acreage planted or harvested for 91 crops. The State forecast also provides yield and production estimates for 12 crops. Appendix Table A-2 displays a list of the crop types available. Production forecasts are also available for several U.S. livestock categories (i.e., bovine, swine, poultry, and dairy) at the national level. Table III-3 displays the indicators provided by WEFA's U.S. livestock analysis. Both the agriculture and livestock forecasts extend through 2010.

WEFA also provides passenger car and light truck forecasts of units produced by plant, location, make, and model. Data are also available at the National level for medium trucks, heavy trucks, truck trailers, and freight cars. In terms of forecasts for the steel industry, currently WEFA forecasts steel production by production process at the national level; however, WEFA can increase the geographic detail to provide forecasts for the eight major producing districts in the United States.

In addition, WEFA's Energy Outlook service provides both forecast data and analysis of the coal, petroleum, electrical, and natural gas markets. Forecasts, which are provided at an annual frequency, extend to 2020 and are performed at either the National level or the Census Region level. WEFA's Natural Gas Outlook provides coverage of demands by sector and region as well as production by basin. The Electric Power Outlook assesses demand, capacity, utilization, transfers, and prices. At the county level, WEFA has developed the Electricity Market

Intelligence Data Service and the Natural Gas Market Intelligence Data Service. Table III-4 provides more detailed information on the geographic scope and forecast information provided by the various energy services. It is important to note, however, that WEFA forecast data do not provide more fuel or geographic-specific data than DOE's official energy projections.

WEFA also provides forecasts of housing starts at the county level. These data, which are classified into single-family units and multi-family units categories, are available at an annual frequency through 2010.

Table III-3. WEFA Livestock Forecasts

Bovine	Swine	Poultry	Dairy
Cattle on Feed	Total Hog Inventories	Broiler F.I. slaughter	Number milk cows
Inventory	Breeding hogs	Broiler F.I. production	Milk production
Placed on feed	Market hogs	Turkeys F.I. slaughter	
Fed marketings	Sows farrowing	Turkeys F.I. prodn.	
Other	Pig Crop	Egg production	
Total Cattle Slaughter	Total Hog Slaughter		
Steers & Heifers	Barrows and gilts		
Cow & bull	Sows & boars		
Calf Slaughter	Pork production		
Beef Production			
Veal Production			
Beef & veal Production			
Calf Crop			
Cattle Inventory			
Calf Inventory			
All Cattle & Calves on Farm			
Cattle & Heifers that calved			
Beef cows			
Milk cows			
Heifers over 500 lbs			
Beef Cow Replacements			
Milk Cow Replacements			
Other Heifers			
Steers over 500 lbs			
Bulls over 500 lbs			
Calves under 500 lbs			

Notes: Beef, veal, beef and veal, pork, broiler, turkey, and milk production are measured in pounds.
Egg production is measured in dozens produced.
All other indicators are measured in animal units.

b. Other Data

WEFA also produces forecasts of dollar output (sales) by industry. These data, which currently extend through 2009, are generally available at the 4-digit SIC code level. These forecast data are produced at the county and zip code level. A separate WEFA service provides employment forecasts at the 3-digit SIC code level. These county-level forecast data are currently available through the year 2010.

2. Obtaining WEFA Forecast Data

Table III-4 summarizes information on the various WEFA forecast services that could be helpful in developing forecast emissions activity data. This table identifies the purchase price for each WEFA forecast series. WEFA offers package and volume discounts, the size of the discount will depend on the package of services to which a user subscribes. As identified in Table III-4, WEFA notes potential forecast service enhancements that they could provide. In many cases, these enhancements include extension of the forecast series through the year 2025. Additional information on procuring WEFA services is available at http://www.wefa.com.

G. MARKET RESEARCH DATA

In addition to looking at the economic forecasting companies described above, EPA examined market research firms as sources of surrogate forecast emissions activity data. Because certain market research companies focus on specific industries (for example, SRI Consulting focuses on chemical and energy related industries), these companies may be able to provide detailed information not available from economic forecasting firms.

This section begins with an overview of the identified market research firms. This is followed by a summary of these firms' published studies that are relevant to emissions forecasting. This section concludes with a comparison of National-level emission growth factors for major VOC-emitting source categories. This analysis compares growth factors based on EGAS 4.0 forecast data with growth factors based on Freedonia Group, Inc. (Freedonia) forecast data. This comparison was performed using Freedonia data because this source focuses on industrial sector market research and because of the relative low cost of obtaining these data.

1. Overview of Market Research Firms Identified

To a greater degree than the forecasts available from economic forecasting firms (e.g., REMI, DRI, RFA), market research forecast data are specific to the products and processes that relate to emissions activities. For example, REMI models, which are the basis for emission growth factors for most of the source categories in EGAS, provide output and employment forecasts by 2 or 3-digit SIC code. In EGAS, for example, the growth factor for SCC 2415300370 - *Solvent Utilization, Degreasing, All Industries: Cold Cleaning, Special Naphthas* is based on output in the Durables Manufacturing sector. The REMI models included in EGAS Version 4.0 forecasts National-level growth of approximately 40 percent in U.S. Durables Manufacturing output over the next 10 years. However, Freedonia has forecast the future National demand for special naphthas used in cold cleaning, and projects an approximate

Table III-4. Overview of WEFA Forecasts

Forecast	List Price[1]	Forecast Period	Geographic Scope	Forecast Information	Potential Enhancements
Macroeconomic: Employment	$10,000	Through 2010	County	Number of employees by industry type at the 3-digit SIC code level	Extend forecast through 2025.
Macroeconomic: Housing Starts	$10,000	Through 2010	County	Number of housing starts by total units, single-family units, and multiple-family units	Extend forecast through 2025.
Macroeconomic: Households	$10,000	Through 2004	County	Total number of households	Extend forecast through 2025.
Business Demographics Database	$84,000	Through 2009	County and zip code	Employment, number of establishments, and sales (in real dollars). Data are available at the 4-digit SIC code level. Zip code and county level forecasts are consistent with WEFA's State level and national level forecasts of activity.	Extend forecast through 2025.
Agriculture Service: Crops	$10,000	Through 2010	State and county	County level forecasts of area planted or harvested for 56 crops and State level forecasts of yield and production estimates for 12 crops and of area planted or harvested for 91 crops	Extend forecast through 2025.
Agriculture Service: Livestock	$3,000	Through 2010	National	Bovine, swine, poultry, and dairy production	Expand the livestock forecasts to the county level and extend the forecast through 2025.
Automotive Service	$7,500	Through 2005	By plant and location	Units produced by plant, location, make, and model in the United States for 12 passenger cars and 8 light truck segments	Extend forecast through 2025.
Energy Service: Electricity	$25,000	Through 2025 at 5-year increments.	By county, by industry	Electricity production, by units, by utility plant and the type of fuel used by the plant. Electricity and natural gas consumption by county by industry at the 2-digit SIC code.	Expand forecast frequency to annual basis and energy demand to include other fuel types.
Energy Service: Coal	$7,000 for package of coal, natural gas, & oil	Through 2025	Coal production basin (e.g., N.E. Appalach. basin) for steam coal and National level for metallurgical coal.	Coal production (in tons)	
Energy Service: Natural Gas	$7,000 for package of coal, natural gas, & oil	Through 2025	Appalachia, California, East North, East South, Gulf Coast, Mid-Continent, Rocky Mountain, Permian, San Juan, West North, Canada	Production (in cubic feet)	None

Table III-4 (continued)

Forecast	List Price[1]	Forecast Period	Geographic Scope	Forecast Information	Potential Enhancements
Energy Service: Oil	$7,000 for package of coal, natural gas, & oil	Through 2025	Lower 48 States, Alaska	Production (barrels per day)	None
Fertilizer Service	$2,000	Through 2003	National	Production of primary fertilizer nutrients (nitrogen, phosphate, and potash)	Expand production forecasts to the State level and extend the forecast period to 2025.
Freight Car Service	$4,000	Through 2005	National	Freight car deliveries by car type. Car types include gondolas, box cars, covered hoppers, flat cars, open hoppers, and other.	Extend forecast through 2025
Steel Forecast	$4,000	Through 2009	National	Steel production (in tons) by process (blast oven furnace and electric arc). Also total shipments, domestic sales, exports, imports, and consumption (in tons)	Expand steel production by process forecasts to 8 major producing districts & extend the forecast period to 2025.
Truck Service	$4,000	Through 2005	National	Retail sales and factory sales by gross vehicle weight (GVW). WEFA segments the truck market into heavy and medium width trucks [e.g., GVW 4 (14,001-16,000 lbs).	Provide plant level forecasts of trucks and extend the forecast period through 2025
Truck Trailer Service	$4,000	Through 2005	National	Shipments (production) by trailer type. Truck trailers include: complete trailers, van trailers, other trailers (tank, platform, low-bed, dump, other), detachable equipment.	Extend forecast through 2025

Notes: [1] Package and volume discounts may be applied for procuring multiple services.

50 percent decline in this activity over the next 10 years. The reason for this discrepancy is that the Freedonia forecasts account for projected shifts in the types of degreasing operations and the types of solvents used for cold cleaning operations. Although market research data, such as that available from Freedonia, are generally not available on a sub-national level, these sources provide forecast data that are more specific to the particular emission source category, and should therefore better reflect changes in future emissions activity.

The summary of each identified market research firm addresses the following general topics:

- Purchasing options/prices;
- Content;
- Forecast period; and
- Update frequency.

Business Communications Company, Inc. (http://buscom.com/)

Business Communications Company, Inc. (BCC) analyzes market, economic, and technological developments to produce marketing reports for numerous industries, with special emphasis placed on advanced materials. Among these industries are: chemicals; packaging; materials; processing; biotechnology; electronics; telecommunications; waste/water/air; energy; and transportation. BCC reports generally contain base year data as well as 2- and 5-year forecasts. Some reports also contain historical data. BCC's reports emphasize future trends and changing technology and opportunities, and provide information on product consumption and supply. The geographic scope of the reports vary. Some reports cover worldwide market trends and dynamics, while other reports focus on the U.S. market at the National level. Some of the U.S. market reports also provide limited information on international markets in order to address the global nature of product markets. Select U.S. reports may provide detail at a sub-regional level, but these reports are atypical. Reports are generally updated every four years.

The cost of BCC products range from $1,500 to approximately $3,500, with most reports costing approximately $3,000. Reports are also available electronically. Prices for electronic copies depend on the number of users. Discounts are offered for purchases of multiple titles.

The Freedonia Group, Inc. (http://www.freedoniagroup.com)

The Freedonia Group, Inc. (Freedonia) produces numerous market research reports covering a variety of industry sectors, focusing on industrial and technical markets. In developing its forecasts, Freedonia analysts interview key industry participants and analyze association information, government data, and trade literature. Studies cover entire industry sectors as well as key niche markets. Some of the industries covered by Freedonia include chemicals; construction; solvents; communications; pharmaceuticals; packaging; and plastics. Each study includes both historical and forecast market information. Although the titles of Freedonia reports imply that forecasts extend five years, most of these reports provide 10-year forecasts of production and demand. For example, the 1999 report "Adhesives to 2003," contains forecasts through the year 2008. Geographic coverage of Freedonia forecasts are generally global or national.

Freedonia reports are approximately $3,000 to $4,000, however, customers may purchase individual chapters or data records at a significantly reduced rate. Chapters, such as "Solvents by Type and Market" within the "Solvents to 2003" report, are available for approximately $500 to $1,000. Individual records, such as "Solvents Demand by Type (million pounds) 1989-2008," are $25. These "records" contain either tabular data or supporting text describing historical and future trends in supply, demand, and prices. The Freedonia web-site has search capabilities so that chapters and records containing references to particular emission activities (e.g., perchloroethylene) can be easily identified. Freedonia studies are typically updated every 3 years, although update cycles differ across studies.

Frost and Sullivan (http://www.frost.com)

Frost & Sullivan provides market research that monitors and forecasts emerging market trends. The company publishes more than 270 market reports annually, many of which examine high-technology industries. Its research reports cover market segments within the healthcare, pharmaceutical, energy, environment, aerospace and defense, telecommunications, information technology, chemicals, electronics, semiconductor, and automotive industries. The geographic scope of the reports cover the United States, Europe, Latin America, or Asia. U.S. reports provide data only at the National level. Reports typically provide data covering a 10-year period (3 years of historical data and 7 years of forecast data). Reports are not updated on any particular schedule. Some reports may be updated every 18 months to 3 years, depending on client interest, while other reports may only be published once.

The price of Frost and Sullivan reports varies from approximately $3,000 to $4,500. Reports may be downloaded electronically from Frost and Sullivan's website. Frost and Sullivan also offers an on-line subscription service for particular segments which allows clients to search by keywords and to view reports on-line. In addition, Frost and Sullivan conducts proprietary reports for clients. The cost of these reports varies depending upon the needs of the client.

Kalorama Information LLC (http://www.marketresearch.com, http://www.findexonline.com)

Kalorama Information LLC distributes syndicated market research reports and is a business-to-business publisher. Through its MarketResearch.com division, Kalorama has access to over 5,000 publications, making it one of the larger distributors of market research publications. Kalorama also owns two companies that develop market research studies: Specialists in Business Information and Packaged Facts.

Specialists in Business Information (SBI)

SBI produces comprehensive profiles on a wide range of industrial and consumer markets. The profiles consist primarily of tabular data. Market profiles include extensive data and summary analyses of shipment trends, product line shipments, imports, exports, factors affecting demand, industry structure, and profiles of leading competitors. SBI's profiles are based on analysis of U.S. government data as well as industry trade statistics. Forecast data extend up to 5 years by product segment, and historical data are also provided. Data are generally national in scope, and are updated approximately every 2 years.

U.S. and global markets covered by SBI include the following industry sectors: food and beverages; consumer and leisure products; building materials; machinery and industrial supplies; and home furnishings.

Prices for SBI reports range from approximately $600 to $2,750 (older reports tend to be less expensive). Reports may be purchased on-line at Kalorama websites, including http://www.marketresearch.com and http://www.findexonline.com. They may also be purchased by searching for Kalorama products on International Market Research Mall's website, ecnext.imrmall.com. Report information can also be accessed by chapter and page at reduced costs (e.g., the per page cost is $30).

Packaged Facts

This research group has a long history of producing market research reports focusing on a wide range of consumer markets. The industry sectors covered by these reports include: beverages; food, health and beauty products; home furnishings; household chemicals; lawn and garden products; and pharmaceuticals. Packaged Facts reports contain information on product and market trends, including data on the historical and forecast growth of the market, and factors affecting future growth and market composition. Most Packaged Facts reports cover the U.S. market, but also include information on global market trends. As with SBI reports, Packaged Facts reports are generally updated on a 2-year cycle and provide up to 5 years of forecast data.

Prices for Packaged Facts reports range from approximately $2,750 to $3,250. Reports may be purchased on-line at Kalorama websites, including http://www.marketresearch.com and http://www.findexonline.com. They may also be purchased by searching for Kalorama products on International Market Research Mall's website, ecnext.imrmall.com. Report information can also be accessed by chapter at a reduced rate and for $30 per page of information.

SRI Consulting (http://www.sriconsulting.com)

SRI Consulting produces two major sets of chemical industry market research data: *Chemical Economics Handbook* and *World Petrochemicals*.

Chemical Economics Handbook

The *Chemical Economics Handbook* (*CEH*) is a chemical marketing and business research service. This service evaluates supply/demand relationships and analyzes the competitive environment for approximately 300 chemical products and product groups. Among the chemical products and product groups included in *CEH* are:

- Amino acids;
- Ammonium nitrate;
- Paper and allied products industry;
- Propylene glycols;
- Sulfuric acid; and
- Xylenes.

CEH reports include information on past and future producer capacity, supply/demand, and prices. The geographic scope of the reports covers the United States, Western Europe, and Japan. Each report provides a 3-year forecast, and the reports are updated approximately every 3 years.

The *CEH* is published in 38 loose-leaf binders. Subscribers to the *CEH* receive a packet of updated reports every month. The *CEH* is also available on CD-ROM, which is updated quarterly. In addition, the *CEH* web site (http://ceh.sric.sri.com) is updated monthly. An introductory one-year subscription to the entire *CEH* reports set costs $39,700. The annual renewal fee is $27,900, which entitles a client to three complete sets. In addition, individual reports can be purchased that cover specific chemical products/product groups. Prices for the individual chemical reports vary from approximately $1,000 to $3,000 (on-line reports are offered at a 10 percent discount compared to the cost of the hardcopy reports). Furthermore, clients may purchase some individual reports by sections (for example, a section describing supply and demand). Supply and demand report sections covering the United States cost approximately $1,000 to $1,500. The supply and demand sections comprise a large portion of each report, which explains the high cost of a section relative to the cost of an entire report.

World Petrochemicals

SRI Consulting also produces the *World Petrochemicals* (*WP*) Program. This service provides supply/demand and capacity analysis for 55 petrochemicals and plastics worldwide. Production capacity information is available for an additional 39 products. The Refined Products section reports supply, demand, and capacity for 12 products and includes capacity data for an additional 24 processes and products. *WP* reports, which are organized by petrochemical product, provide detailed information on capacity production, consumption, and major consuming industries. The reports provide supply and demand data with 5 years of history and 10-year forecasts. The U.S. data are available at the national level, although some products provide limited company and State data through searches of *WP*'s database. SRI updates its *WP* and segment reports on an annual basis. A sample of the products covered include: acetone, benzene, cyclohexane, ethylene, methyl methacrylate, phthalic anhydride, and mixed xylenes.

The *WP* data are available in both printed and electronic formats. Individual product reports can be purchased either from the *WP* web site (http://wp.sric.sri.com), or by directly contacting *WP*. Prices for hardcopy individual reports on plastics, petrochemicals, and refined products range from $1,500 to $3,500. Certain plastic and petrochemical reports may be purchased in groups, with these prices ranging from $5,200 to $8,800. Additional aggregations are available by seven product segments. The price of these reports varies with the number of segments purchased – the first segment price is $18,300 and the seventh segment price is $11,600. The number of chemical products included in a segment varies from 7 to 26. All *WP* reports that are purchased electronically receive a 10 percent discount. The complete *WP* program may also be purchased as an interactive electronic database that can be installed on individual or network computers. The cost of this data base ranges from $34,900 for the first segment to $13,000 for the seventh segment.

2. Market Research Forecast Data Applicable to Emission Source Categories

The purpose of this section is to highlight specific market research studies and data that provide forecast information of potential use as surrogate forecast emissions activity data. The discussion is organized into two sub-sections – the first providing a list of market research studies identified as having information that can potentially be used in forecasting emissions; the second presents the results of comparisons between Freedonia-based National growth factors with EGAS 4.0-based factors. These comparisons were developed for the top emitting source categories in EPA's 1996 National Emission Trends inventory.

a. Market Research Reports

Appendix Table A-3 lists the titles of market research reports with potential applicability for emissions forecasting. Although some of these reports appear dated, many of the studies are due to be updated in the near future. The bulk of the relevant studies pertain to source categories within the chemical industry, however, forecasts are also available for a diverse set of categories including recreational vehicles and the pulp and paper industry. In the vast majority of instances, available forecast data are national or global in scope. For a small number of studies, U.S. regional data are also available (e.g., Freedonia Group, Inc.'s "Roofing to 2003").

b. Comparison of Market Research Data with EGAS 4.0 Data

The following sub-sections describe comparisons between growth factors developed from EGAS 4.0 data and growth factors based on forecasts from the Freedonia Group, Inc. (Freedonia) Comparisons are presented for source categories with available Freedonia data. To narrow the scope of the analysis, research was conducted into the availability of Freedonia data for the top VOC, NO_x, and $PM_{2.5}$ emitting source categories (excluding on-road mobile sources).

i. Top 50 VOC-emitting Categories

As a test of the availability of market research data as potential surrogate forecast emission activity data, the EIIP Projections Committee developed a list of the top 50 VOC source categories as identified from 1996 emissions reported in the NET inventory. The Committee searched the data base of Freedonia market research studies based on the description of the emissions activity associated with each of the top VOC-emitting categories. If no relevant information was found, the Committee searched the Freedonia studies based on the description of the source category. For example, emissions for SCC 2260001000 (Off-Highway Vehicle Gasoline, 2-Stroke; Recreational Vehicles; Total) are based on thousands of gallons of gasoline burned by these vehicles. Because a search of the Freedonia reports identified no forecasts of this activity, the Committee searched for, and located, forecast data on dollar shipments of recreational vehicles. Since the Freedonia forecast data are only reported each 5 years over a 10-year forecast period, the Committee developed growth factors from the Freedonia base year (for the most part, either 1997 or 1998) to the two forecast years. In the recreational vehicle example, the Committee compared the growth factors from the Freedonia series to EPA's draft NONROAD model growth factors for this SCC, which are also only available at a National level.

In cases where EGAS 4.0 growth factors are based on REMI output projections, the Committee developed a National REMI forecast run using the National model that is consistent with the REMI regional economic forecasts incorporated into EGAS 4.0 (EGAS 4.0 does not develop National-level REMI-based growth factors). The Committee identified relevant Freedonia forecast data for approximately one-half of the Top 50 VOC-emitting source categories.

Table III-5 presents the results of the EGAS 4.0 and Freedonia growth factor comparisons. It should be noted that for the Freedonia forecasts that are expressed in dollar terms (e.g., recreational vehicle shipments), the Committee determined if these data represented nominal or constant dollars. In cases where forecasts were expressed in nominal dollars, the Committee identified Freedonia price forecasts relevant to these categories and adjusted the forecasts to constant dollar terms. The nine SCCs in boldface type are associated with EGAS and Freedonia growth factors with the largest discrepancies. These SCCs have at least 1 year where the forecast growth from one of the two indicators is at least 25 percent higher or lower than the alternative indicator. Focusing on these SCCs, there is only one SCC with a Freedonia-based growth factor higher than an EGAS-based growth factor. The EGAS growth factor for this SCC (24401008000–Surface Coating, Traffic Marking, Total: All Solvent Types), is associated with an adjustment to the REMI dollar output projection. Specifically, EGAS incorporates an adjustment for this SCC to reflect the historical relationship between REMI dollar output and emissions activity data.

Of the eight SCCs with substantially lower Freedonia growth factors, the EGAS-based growth factors are less directly related to the emissions activity than the Freedonia data. For example, the EGAS growth factor for SCC 2440020000 (Miscellaneous Industrial Adhesive Application; Total: All Solvent Types) is based on Total Manufacturing sector dollar output forecasts while the Freedonia data is based on the projected demand for solvent-based adhesives (in pounds). The 1998–2008 EGAS-based growth factor for this SCC is 1.424 while the Freedonia-based growth factors is 0.898. For these source categories, it appears that the Freedonia growth factors are preferable to the EGAS growth factors.

It should also be noted that Table III-5 reports a number of surface coating SCCs for which growth factors are based on the forecast amount of coatings sold. These coatings data are specific to the application in which they are used (e.g., automotive refinishing coatings demand). Freedonia also develops coatings demand forecasts for "solvent-based," "water-based," and "other" coating categories. Because the amount of solvent being used is the key emissions-related concept, these alternative data provide detail that is not provided in the data reported in Table III-5. However, the available "solvent-based" coatings data are generally reported at much less application detail than the total coatings data. For example, forecast data are available on the use of "solvent-based" versus "water-based" versus "other coating types" within the total maintenance and specialty coatings category. Because traffic coatings are included in this category, an alternative projection for the traffic coatings category based on this forecast, would yield a 10 percent reduction in emissions activity from 1997 to 2007. This contrasts sharply with the 27 percent increase reported for maintenance and speciality coatings demand and the 36 percent increase forecast for traffic coatings demand.

Table III-5. Comparison of Growth Factors Derived from EGAS 4.0 and Freedonia Forecast Data: VOC Categories

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2004	2007	2008	2009	Growth Factor Basis
			Freedonia		1.040			1.057		Recreational Vehicle Shipments ($)
	Mobile Sources Off-Highway Vehicle Gasoline, 2-Stroke Recreational Vehicles	1998	EGAS		1.029			1.068		EPA's Nonroad Model - Recreational, Gasoline Engine Population
2260001000	Total		% Difference		1.1 %			-1.0 %		
			Freedonia	1.141			1.319			Lawn Mowers Sold ($)
	Mobile Sources Off-Highway Vehicle Gasoline, 4-Stroke Lawn & Garden	1997	EGAS	1.113			1.230			EPA's Nonroad Model - Lawn & Garden, Gasoline Engine Population
2265004010	Equipment Lawn mowers (Residential)		% Difference	2.5 %			7.3 %			
			Freedonia	1.133			1.300			Lawn & Garden Tractor Shipments ($)
	Mobile Sources Off-Highway Vehicle Gasoline, 4-Stroke Lawn & Garden	1997	EGAS	1.113			1.230			EPA's Nonroad Model - Lawn & Garden, Gasoline Engine Population
2265004055	Equipment Lawn & Garden Tractors (Residential)		% Difference	1.8 %			5.7 %			
			Freedonia		1.252					Electric Motors & Generators Sold ($)
	Mobile Sources Off-Highway Vehicle Gasoline, 4-Stroke Light Commercial	1998	EGAS		1.176					EPA's Nonroad Model - Light Commercial, Gasoline Engine Population
2265006005	Generator Sets		% Difference		6.6 %					
			Freedonia			1.026			1.081	Oil & Gas Produced (quadrillion Btu)
	Industrial Processes Oil & Gas Production: SIC 13 All Processes Total:	1999	EGAS			1.172			1.275	Output in Oil & Gas Production ($)
2310000000	All Processes		% Difference			-12.5 %			-15.2 %	
			Freedonia	0.833			0.700			Solvent-based Architectural Coating Shipments ($)
	Solvent Utilization Surface Coating Architectural Coatings Total: All	1997	EGAS	1.040			1.073			Output in Paints and Allied Products ($) adjusted based on regression
2401001000	**Solvent Types**		% Difference	-19.9 %			-34.8 %			

Table III-5 (continued)

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2004	2007	2008	2009	Growth Factor Basis
2401005000	Solvent Utilization Surface Coating Auto Refinishing: SIC 7532 Total: All Solvent Types	1997	Freedonia	1.032			1.064			Automotive Refinish Coatings Sold (gallons)
			EGAS	0.994			0.995			Output in Auto. Parking, Repair, & Services ($) adjusted based on regression
			% Difference	3.8 %			7.0 %			
2401008000	**Solvent Utilization Surface Coating Traffic Markings Total: All Solvent Types**	1997	Freedonia	1.194			1.355			Traffic Coatings Sold (gallons)
			EGAS	1.040			1.073			Output in Paints and Allied Products ($) adjusted based on regression
			% Difference	14.8 %			26.3 %			
2401020000	Solvent Utilization Surface Coating Wood Furniture: SIC 25 Total: All Solvent Types	1997	Freedonia	1.152			1.318			Wood Furniture and Fixture Coatings Shipments (gallons)
			EGAS	1.394			1.619			Output in Furniture and Fixtures ($)
			% Difference	-17.4 %			-18.6 %			
2401040000	**Solvent Utilization Surface Coating Metal Cans: SIC 341 Total: All Solvent Types**	1997	Freedonia	0.962			0.906			Can & Container Coatings (gallons)
			EGAS	1.193			1.464			Output in Metal Cans and Shipping Containers ($)
			% Difference	-19.4 %			-38.1 %			
2401070000	**Solvent Utilization Surface Coating Motor Vehicles: SIC 371 Total: All Solvent Types**	1997	Freedonia	1.059			1.134			Motor Vehicle Coatings (gallons)
			EGAS	1.242			1.549			Output in Motor Vehicles and Equipment ($)
			% Difference	-14.7 %			-26.7 %			
2401100000	**Solvent Utilization Surface Coating Industrial Maintenance Coatings Total: All Solvent Types**	1997	Freedonia	0.991			0.896			Solvent-based Maintenance & Specialty Coatings Demand (gallons)
			EGAS	1.176			1.391			Output in Total (Durable/Nondurable) Manufacturing ($)
			% Difference	-15.8 %			-35.6 %			
2401200000	Solvent Utilization Surface Coating Other Special Purpose Coatings Total: All Solvent Types	1997	Freedonia	0.991			0.896			Solvent-based Maintenance & Specialty Coatings Demand (gallons)
			EGAS	1.040			1.073			Output in Paint and Allied Products ($) adjusted based on regression
			% Difference	-4.7 %			-16.5 %			

Table III-5 (continued)

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2004	2007	2008	2009	Growth Factor Basis
			Freedonia			0.931			0.884	Industrial & Institutional Cleaners Solvents Demand -- Electronics ($)
	Solvent Utilization Degreasing Electronic & Other Elec. (SIC 36): Open Total: All Solvent Types	1999	EGAS			1.395			1.735	Output in Electrical Equipment ($)
2415130000			% Difference			-33.3 %			-49.0 %	
			Freedonia		0.658			0.395		Special Naphthas Used in Dry Cleaning (lbs)
	Solvent Utilization Dry Cleaning Commercial/Industrial Cleaners Special Naphthas	1998	EGAS		1.100			1.194		Output in Laundry, Cleaning, and Shoe Repair ($)
2420010370			% Difference		-40.2 %			-66.9 %		
			Freedonia		1.071			1.167		Solvents Used in Printing Inks (lbs)
	Solvent Utilization Graphic Arts All Processes Total: All Solvent Types	1998	EGAS		1.163			1.300		Output in Commercial Printing and Business Forms ($)
2425000000			% Difference		-7.9 %			-10.3 %		
			Freedonia		0.952			0.898		Solvent-Based Adhesives Demand (lbs)
	Solvent Utilization Miscellaneous Industrial Adhesive (Industrial) Application Total: All Solvent Types	1998	EGAS		1.208			1.424		Output in Total (Durable/Nondurable) Manufacturing ($)
2440020000			% Difference		-21.2 %			-36.9 %		
			Freedonia		1.051			1.081		Cutback Asphalt Demand (tons)
	Solvent Utilization Miscellaneous Non-Industrial: Commercial Cutback Asphalt Total: All Solvent Types	1998	EGAS		1.144			1.270		Output in Commercial Sector (FIRE, Retail and Wholesale Trade, Services) ($)
2461021000			% Difference		-8.1 %			-14.9 %		
			Freedonia		1.017			1.098		Solvents Used in Consumer Products (lbs)
	Solvent Utilization Miscellaneous Non-Industrial: Consumer All Products/Processes Total: All Solvent Types	1998	EGAS		1.042			1.083		Population
2465000000			% Difference		-2.4 %			1.3 %		
			Freedonia		1.052			1.111		Solvents Used in Toiletries, Cosmetics, Drugs (lbs)
	Solvent Utilization Miscellaneous Non-Industrial: Consumer Personal Care Products Total: All Solvent Types	1998	EGAS		1.042			1.083		Population
2465100000			% Difference		1.0 %			2.6 %		

Table III-5 (continued)

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2004	2007	2008	2009	Growth Factor Basis
2465200000	Solvent Utilization Miscellaneous Non-Industrial: Consumer Household Products Total: All Solvent Types	1998	Freedonia		1.104			1.294		Solvents Used in Household Cleaners (lbs)
			EGAS		1.042			1.083		Population
			% Difference		6.0 %			19.4 %		
2465400000	Solvent Utilization Miscellaneous Non-Industrial: Consumer Automotive Aftermarket Products Total: All Solvent Types	1997	Freedonia	1.046			1.114			Motor Vehicle Refinish and Aftermarket Coatings (gallons)
			EGAS	1.042			1.084			Population
			% Difference	0.3 %			2.7 %			
2465600000	Solvent Utilization Miscellaneous Non-Industrial: Consumer Adhesives and Sealants Total: All Solvent Types	1998	Freedonia		0.952			0.898		Solvent-Based Adhesives Demand (lbs)
			EGAS		1.041			1.083		Population
			% Difference		-8.6 %			-17.1 %		
2465900000	**Solvent Utilization Miscellaneous Non-Industrial: Consumer Miscellaneous Products: NEC Total: All Solvent Types**	1998	Freedonia		0.625			0.312		Solvents Demand for Other Consumer Product Applications (lbs)
			EGAS		1.041			1.083		Population
			% Difference		-40.0 %			-71.1 %		

Note: SCCs in boldface type have at least one forecast year where the growth rate is at least 25 percent higher/lower based on Freedonia forecast data versus EGAS 4.0 forecast data.

ii. Top 25 NO_x-emitting Categories

Table III-6 presents the EGAS-Freedonia growth factor comparisons for the top NO_x-emitting source categories in the 1996 NET inventory. Freedonia provides forecast data for less than one-third of the top 25 NO_x categories. None of these categories is associated with a growth rate that is 25 percent higher from one source than the other. Of the seven categories with available Freedonia data, Freedonia data are higher for three categories, while EGAS data are higher for four categories. Two of the three categories with higher Freedonia forecasted growth have EGAS growth based on REMI output projections adjusted based on a historical regression analysis. Because the EGAS growth factors for these categories are based on projections for the specific emissions activity (i.e., amount of diesel fuel burned), rather than engine population projections, the EGAS-based growth factors may be better surrogate growth indicators. Of the remaining categories, it is particularly unclear if one or the other data source is preferable because each represents the same level of detail. For example, SCC 2270002069 (Off-Highway Vehicle, Diesel, Construction Equipment, Crawler Tractors) is associated with construction equipment diesel engine demand forecasts from both sources. It should be noted that the Freedonia forecast data may better reflect future trends because the EGAS forecasts are simply based on a continuation of recent past engine population growth rates.

iii. Top 25 $PM_{2.5}$-emitting Categories

Table III-7 displays the growth factor comparisons for the top $PM_{2.5}$-emitting source categories. Freedonia provides forecast data for less than one-third of the top 25 $PM_{2.5}$ categories. None of these categories is associated with a growth rate that is 25 percent higher from one source than the other. Of the seven categories with available Freedonia data, Freedonia data are higher for five categories, while EGAS data are higher for two categories. Three of the five categories with higher Freedonia forecasted growth have EGAS growth based on REMI output projections adjusted based on a historical regression analysis. Because the EGAS growth factors for the two nonroad source categories are more specific to the emissions activity, the EGAS-based growth factors may be better surrogate growth indicators for these categories. It is not clear if the Freedonia or EGAS growth factor for the other SCC (28801000003–Agriculture Production -Crops, Agriculture - Crop Tilling) is preferable. Although the EGAS growth factor is based on an acres of crops tilled forecast based on the historical relationship between farm output and crops tilled, the Freedonia data do not include all crop types. For the two categories with higher Freedonia growth factors, it is particularly unclear if one or the other data source is preferable because each represents the same level of detail. However, the Freedonia forecast data may better reflect future trends because the EGAS forecasts are simply based on a continuation of recent past engine population growth rates.

Table III-6. Comparison of Growth Factors Derived from EGAS 4.0 and Freedonia Forecast Data: NO_x Categories

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2007	2008	Growth Factor Basis
2280002000	Mobile Sources Marine Vessels, Commercial Diesel Total, All Vessel Types	1998	Freedonia		1.1437		1.3424	Marine Equipment Diesel Engine Demand ($)
			EGAS		1.0698		1.1140	Output in Water Transportation ($) adjusted based on regression
			% Difference		6.9 %		20.5 %	
2285002000	Mobile Sources Railroads Diesel Total	1998	Freedonia		1.0961		1.2253	Other Markets Equipment Diesel Engine Demand ($)*
			EGAS		1.0025		1.0319	Output in Railroad Transportation ($) adjusted based on regression
			% Difference		9.3 %		18.7 %	
2270005015	Mobile Sources Off-Highway Vehicle Diesel Farm Equipment Agricultural Tractors	1998	Freedonia		1.2065		1.3846	Agricultural Equipment Diesel Engine Demand ($)
			EGAS		1.1411		1.2764	EPA's Nonroad Model- Farm, Diesel Engine Population
			% Difference		5.7 %		8.5 %	
2270002069	Mobile Sources Off-Highway Vehicle Diesel Construction Equipment Crawler Tractors	1998	Freedonia		1.0777		1.1798	Construction Equipment Diesel Engine Demand ($)
			EGAS		1.1497		1.3007	EPA's Nonroad Model- Construction, Diesel Engine Population
			% Difference		-6.3 %		-9.3 %	
2270002060	Mobile Sources Off-Highway Vehicle Diesel Construction Equipment Rubber Tire Loaders	1998	Freedonia		1.0777		1.1798	Construction Equipment Diesel Engine Demand ($)
			EGAS		1.1497		1.3007	EPA's Nonroad Model- Construction, Diesel Engine Population
			% Difference		-6.3 %		-9.3 %	

Table III-6 (continued)

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2007	2008	Growth Factor Basis
2270002066	Mobile Sources Off-Highway Vehicle Diesel Construction Equipment Tractors/Loaders/Backhoes	1998	Freedonia		1.0777		1.1798	Construction Equipment Diesel Engine Demand ($)
			EGAS		1.1497		1.3007	EPA's Nonroad Model- Construction, Diesel Engine Population
			% Difference		-6.3 %		-9.3 %	
2270002051	Mobile Sources Off-Highway Vehicle Diesel Construction Equipment Off-highway Trucks	1998	Freedonia		1.0777		1.1798	Construction Equipment Diesel Engine Demand ($)
			EGAS		1.1497		1.3007	EPA's Nonroad Model- Construction, Diesel Engine Population
			% Difference		-6.3 %		-9.3 %	

Notes: * Includes railroad equipment, nonmarine military equipment, recreational vehicles, and residential generators.

Table III-7. Comparison of Growth Factors Derived from EGAS 4.0 and Freedonia Forecast Data: $PM_{2.5}$ Categories

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to: 2002	2003	2007	2008	Growth Factor Basis
2801000003	Miscellaneous Area Sources Agriculture Production - Crops Agriculture - Crops Tilling	1997	Freedonia	1.0151		1.0392		Crop Acres Planted (million)*
			EGAS	0.9421		0.8866		Output in Farm-SIC 01, 02 ($) adjusted based on regression
			% Difference	7.7 %		17.2 %		
2325000000	Industrial Processes Mining & Quarrying: SIC 14 All Processes Total	1997	Freedonia	1.1155		1.2371		Mining Ore and Waste Handled (million tons)
			EGAS	1.0641		1.1123		Output in Nonmetallic Minerals, Except Fuels ($)
			% Difference	4.8 %		11.2 %		
2270005015	Mobile Sources Off-Highway Vehicle Diesel Farm Equipment Agricultural Tractors	1998	Freedonia		1.2065		1.3846	Agricultural Equipment Diesel Engine Demand ($)
			EGAS		1.1411		1.2764	EPA's Nonroad Model- Farm, Diesel Engine Population
			% Difference		5.7 %		8.5 %	
2280002000	Mobile Sources Marine Vessels, Commercial Diesel Total, All Vessel Types	1998	Freedonia		1.1437		1.3424	Marine Equipment Diesel Engine Demand ($)
			EGAS		1.0698		1.1140	Output in Water Transportation ($) adjusted based on regression
			% Difference		6.9 %		20.5 %	
2285002000	Mobile Sources Railroads Diesel Total	1998	Freedonia		1.0961		1.2253	Other Markets Equipment Diesel Engine Demand ($)**
			EGAS		1.0025		1.0319	Output in Railroad Transportation ($) adjusted based on regression
			% Difference		9.3 %		18.7 %	
2270002060	Mobile Sources Off-Highway Vehicle Diesel Construction Equipment Rubber Tire Loaders	1998	Freedonia		1.0777		1.1798	Construction Equipment Diesel Engine Demand ($)
			EGAS		1.1497		1.3007	EPA's Nonroad Model- Construction, Diesel Engine Population
			% Difference		-6.3 %		-9.3 %	

Table III-7 (continued)

SCC	SCC Description	Base Year	Data Source	Growth Factors from 1996 to:		Growth Factor Basis
			Freedonia	1.0777	1.1798	Construction Equipment Diesel Engine Demand ($)
		1998	EGAS	1.1497	1.3007	EPA's Nonroad Model- Construction, Diesel Engine Population
	Mobile Sources Off-Highway Vehicle Diesel		%			
2270002066	Construction Equipment Tractors/Loaders/Backhoes		Difference	-6.3 %	-9.3 %	

Notes: * includes corn, sorghum, oats, barley, wheat, soybeans, rice, peanuts, sunflowers, Upland and Pima cotton, alfalfa and other hay, potatoes (including sweet), tobacco, sugar beets, canola, and rapeseed.

** Includes railroad equipment, nonmarine military equipment, recreational vehicles, and residential generators.

SECTION IV
CONCLUSION

A. EMISSION PROJECTION TOOLS

1. Overview of Strengths and Limitations

The emission projection tools analyzed in this document can generally be categorized into emission projection tools whose primary purpose is to develop projection year inventories (often as part of control strategy evaluations and State implementation plan development), and emission modeling tools whose primary purpose is to provide emission inputs for air quality models. No single projections tool currently provides a system that serves both objectives ideally. The emission projection tools that are evaluated in this paper are generally much more user-friendly and less resource-intensive than the emission modeling tools. However, none of the emission projection tools currently provide a means for developing emission inputs for air quality models. In addition, the only comprehensive control strategy planning tool developed for the United States, the MPS, is outdated. The emission modeling tools provide the best means for developing inputs for air quality models, however, these tools are not well-equipped for evaluating control strategies and currently involve computer hardware requirements and training that may be beyond the level available to local air quality planning agencies. The remainder of this section provides some general observations concerning the strengths and limitations associated with each of the projection tools evaluated in this paper.

The **CEFS** is a flexible model that can be used as both a control strategy evaluation tool (through its TREND forecast module) as well as a tool for preparing inputs to air quality models (through its GIS forecast model). The CEFS is comprehensive in its coverage of pollutants, source categories, geography, and time frame and generally provides flexibility and sophisticated forecasting approaches. The model will also include default data for all necessary inputs. Unfortunately, the model is specific to California.

Canada's **EFM** has limited default inputs (no emission growth or control factor information), but good model flexibility. The model's use of Canada's Residual Discharge Information System emissions inventory limits its direct use to sources in that country.

ENERGY 2020 provides substantial model flexibility and a means to provide projections based on more geographically detailed emissions activity growth data than are offered by EGAS Version 4.0. This model, however, is proprietary, limited to energy-related sectors, and uses emission projections algorithms that do not account for source-specific data.

Unlike the other U.S. emission projection tools evaluated, the **MPS** was specifically developed by EPA to assist local air agencies in evaluating potential emission control strategies.

Unfortunately, this model only focuses on ozone precursor emissions and does not contain default input data. The MPS also receives poor comprehensiveness and currency evaluations. The low comprehensiveness rating is largely based on the fact that it does not explicitly model the effect of equipment turnover or process changes on future emissions. The low currency rating is due to the fact that it was last updated in 1995, and would require substantial revisions to make it compatible with future EPA inventory file formats (e.g., EPA's NET data base format).

EPA's **NONROAD** model possesses excellent comprehensiveness given the sophistication with which it models future emissions (e.g., use of deterioration factors that estimate rates of emission increase as nonroad equipment ages). The model is flexible in allowing users to input their own data, and in providing users with the ability to run the model for specific areas and source categories. The model is also non-proprietary, contains default data for all necessary input parameters, has the capability to output emissions in EPS-input format, and is a Windows-based product. The two major limitations of the model are that it only covers nonroad source categories and that major default inputs are based on National rather than local data (the NONROAD model user can, however, incorporate local data by modifying the default inputs).

The **EPS** is a non-proprietary mainframe emissions modeling tool. Limitations of EPS include a lack of default control data, its sole focus on criteria pollutants, and relatively non-robust treatment of factors affecting future emission levels (e.g., process changes and deterioration are not explicitly accounted for). Strengths include its flexibility (e.g., the system can be run in a modular function, which means users can develop forecasts without spatially allocating emissions to grid cells) and model detail concerning the ability to model both growth and control factors for individual facilities.

The **EMS-95** must currently be run on a UNIX workstation with a SAS license, requiring a costly investment, however, plans are to create a PC Windows NT version that will significantly reduce costs. Like EPS, EMS-95 focuses on criteria pollutants. Unlike EPS, EMS-95 is inflexible in that base year emissions must first be processed into gridded inventories before developing projections. EMS-95's focus on grid-level hourly emissions output results in EMS-95 being a poor tool for control strategy planning/tracking. Other limitations of EMS-95 include a complete lack of default modeling inputs. Strengths include its flexibility and model detail concerning the ability to input growth and controls at various levels of detail (e.g., the capability to model point source growth and control factors at the facility/device ID level). Unlike EPS, EMS-95 can also explicitly model process changes through the use of new SCCs that are linked to the base year inventory.

The **SMOKE** modeling system is a non-proprietary emissions modeling tool that runs on a UNIX platform (a Windows NT version is planned). Although the model is still being modified, when completed, it should represent a very flexible, robust model for developing emission projections for air quality modeling. Unlike EPS and EMS-95, SMOKE is designed to be used for modeling ozone, particulates, and toxics (however, there is a maximum number of pollutants allowed). Other advantages of SMOKE over the other two emissions modeling tools include its run speed (e.g., SMOKE is estimated to be 35 times faster than EMS-95) and its additional sophistication concerning the modeling of process changes and controls on new sources. As with

EPS and EMS-95, SMOKE was mainly designed to develop grid-level emissions for use as inputs to air quality models. However, SMOKE can optionally output State and county total emissions.

2. Potential Improvements

The purpose of this section is to identify potential areas where emissions projection tools can be improved. Further analysis and discussions with model developers would be necessary before making final recommendations. The general conclusion reached from these evaluations is that the emission projections community may want to consider developing a CEFS-like tool that can serve both as an inventory projection/control strategy planning tool and as a tool for creating necessary inputs to air quality models. SMOKE would seem to provide advantages over the other emission projection tools as the starting point for such a flexible tool. These advantages include its additional flexibility, its more efficient processing, and additional comprehensiveness concerning the factors that affect future emission levels. As an alternative, the emission projections community may want to consider updating the MPS to create a separate inventory projection/control strategy planning tool. MPS updates should focus on including non-ozone precursor pollutants, more sophisticated treatment of factors affecting future emission levels (e.g., process changes), and integration with the NET inventory data base format.

A few observations can be made concerning future directions/improvements for specific models. The ENERGY 2020 model is worthy of consideration for future integration into EGAS. This model provides the capability to forecast energy demand at the county-level, which is more specific than the Census division-level forecasts provided by the DOE. However, ENERGY 2020 does not appear to be a good emission projection tool given its lack of source-specific detail. It may also prove too costly for integration into EGAS. As part of its consideration for integration into EGAS, it would be important to analyze the strengths and limitations of its energy demand modeling approach versus the approach used by DOE. As noted in the ENERGY 2020 evaluation section, documentation of these approaches appears to be very limited.

EPA's NONROAD model is an excellent tool for projecting nonroad source category emissions. In addition to adding nonroad source categories that are currently omitted from the model, EPA may want to consider improvements to the default model input data. For the most part, the NONROAD model inputs are based on National data (e.g., growth factors). The model can be improved to provide more precise measures of local emissions activity if these inputs were based on more regionalized data.

All three emissions modeling tools would be improved by creating PC versions (in fact, plans are underway for such versions for two of the three models) and increasing their capabilities with respect to developing projected inventories for control strategy planning. EMS-95 would likely require the most effort to implement this latter recommendation based on its focus on preparing gridded, hourly emission outputs. In addition, EPS could be improved by incorporating a more sophisticated treatment of factors affecting emissions (e.g., equipment turnover), such as that used by the SMOKE modeling system. Also, both EPS and EMS-95 could be expanded to include non-criteria air pollutants. In addition to generally improving its capabilities with respect to projecting inventories for planning purposes, and implementing planned improvements, the emission projections community should consider supporting better and more complete

documentation of the SMOKE modeling system and the capability to input facility-specific growth factors.

B. EMISSION GROWTH SURROGATE DATA

1. EGAS Strengths and Limitations

EGAS Version 4.0 presents an EPA-approved source of emission growth indicators for nearly 10,000 SCCs. EGAS also outputs emission growth indicators at the 2-digit SIC code level, and provides users with the option of using one of two sets of macroeconomic driver forecasts (i.e., Bureau of Labor Statistics or Wharton Econometric Forecasting Associates). EGAS can also output SCC or 2-digit SIC code growth factors based on BEA forecast data (it is important to reiterate that there are no plans for future updates to BEA's forecast series). EGAS Version 4.0 incorporates changes in projected fuel use and energy efficiency as projected by the DOE, reflects the emissions growth data included in EPA's draft NONROAD model, and projects VMT using EPA-approved methods.

However, EGAS is limited in its ability to model specific local trends and near-term plans which State and local agencies may be aware of. Given the vast number of SCCs it covers, the majority of the growth factors in EGAS are derived directly from sales projections that are developed at the 2- or 3-digit SIC code level. With some exceptions, these sales projections are judgmentally assigned to SCCs based on general knowledge of the source category. As such, EGAS is limited in its ability to forecast individual source category process changes. For source categories that comprise a large percentage of pollutant emissions in a given locality, State and local agencies may want to more closely investigate the availability of forecast information from trade associations, chambers of commerce, market research firms, or other groups that may have more specific knowledge of future levels of emissions activity.

The following section presents some potential improvements that could be implemented in future versions of EGAS or that State and local agencies may consider to supplement the data available from EGAS.

2. Potential Improvements to EGAS 4.0

This discussion is divided into two sub-sections-- the first describing revisions to existing EGAS 4.0 data sources; the second discusses replacement of EGAS data with data from other sources.

a. Revisions to Existing EGAS 4.0 Data Sources

Inputs to Physical Output Module

One potential improvement to the inputs to the physical output module of EGAS 4.0 is to further refine the geographic detail included in EGAS' economic models. The EGAS physical output module currently employs REMI economic models that represent geographic regions associated with ozone nonattainment area designations from 1991. It would be preferable if the

geographic detail in future versions of EGAS was consistent with the needs of State/local air quality planning agencies given new ozone nonattainment area designations under a revised ozone National Ambient Air Quality Standards, and the needs of other air quality planning requirements (e.g., particulate matter). Because REMI has the in-house capability to develop individual economic models for each county in the United States, EGAS can be specified at that level of geographic detail.

Another potential EGAS enhancement is to increase the sectoral detail included in the underlying REMI models. Additional model detail would provide more industry precision in the growth factor estimates. Regional growth in REMI's models is largely a function of the cost competitiveness of local areas compared to the rest of the United States. Although the current REMI models in EGAS Version 4.0 are based on 14-sector cost information, REMI typically develops its models using 53-sector information (172-sector models are also available). Local relative factor costs may be substantially different for a given 2-digit SIC code industry within the 14-sector models included in EGAS Version 4.0. However, the 14-sector models can not model this distinction, since they are constrained by the data at the 14-sector level (1-digit SIC code industry). More accurate forecasts will result from a more detailed representation of relative cost competitiveness.

In addition, there are more up-to-date REMI economic models and WEFA forecast data that are available compared with the models/data incorporated into EGAS 4.0. The EPA should consider incorporating these updated data and provide for regular (annual) updates to EGAS to ensure that the forecast data represent the most up-to-date information available.

It is also possible to procure projections data from REMI and other economic forecasting firms that are disaggregated below the 3-digit SIC code level. This additional detail would allow for a more accurate match between emission source categories and surrogate growth indicators. Before purchasing such data, however, it will be important to understand how these detailed forecasts are developed. It is anticipated that most if not all of these detailed projections are developed by allocating 3-digit SIC code projections to more detailed sectors based on National-level forecasts. It was beyond the scope of this effort to analyze the projections methodologies of each forecasting firm. Other potential refinements to the physical output module of EGAS include the development of additional regression equations relating historical emissions activity data to REMI output data. These regressions establish the correlation between specific REMI sectoral output data and emissions activity data.

Fuel Combustion Sectors

For source categories whose emissions activity is based on fuel consumption, EGAS Version 4.0 develops growth factors based on energy forecasts developed by the DOE. These data are only available at the Census division or National-level. To better estimate relative growth rates within specific counties, States, or other regions, it would be possible to adjust the DOE data for the relative regional growth in a socioeconomic variable that relates to energy demand. For example, personal income growth at the county-level relative to personal income growth at the Census division-level could provide adjustment factors to apply to the DOE Census division-level residential energy forecasts. In addition, DOE has released an updated set of energy projections

that have not been incorporated into EGAS 4.0. The EPA should consider annual updates to EGAS to ensure that the latest set of DOE projections are incorporated.

As noted in Section A.2, EPA may also want to consider integrating the energy demand forecasting capabilities of the ENERGY 2020 model into EGAS. This model would provide more geographically detailed energy demand projections capability, but may be costly to procure and incorporate.

Nonroad Emission Sectors

Analogous to the fuel combustion sector discussion above, EGAS Version 4.0 applies National growth rates from EPA's NONROAD model in developing nonroad sector growth factors. As with the DOE energy projections data, it would be possible to estimate more geographically-specific growth factors based on socioeconomic forecast data available from REMI's models. For example, National residential lawn and garden source category growth could be adjusted based on the ratio of the local population growth rate to the National population growth rate.

VMT

EGAS applies forecasts of total VMT to all VMT source categories. It may be possible to develop VMT estimates by vehicle type and/or road classification to reflect differential growth rates that occur within the total VMT category.

Crosswalk

Although EGAS Version 4.0 includes nearly 10,000 SCCs, there are a number of SCCs that have been added since the EGAS Version 4.0 crosswalk was developed. As with other EGAS modules, it would be helpful to have the EGAS crosswalk updated periodically to ensure that newly developed SCCs will have growth factors available from EGAS. In addition, it would be useful to provide EGAS users with a means to review the EGAS Version 4.0 crosswalk to identify potential refinements to the assignment of surrogate emission growth indicators to SCCs.

b. Replacement of EGAS Data with Data from Other Sources

Certain data sources provide more specific emissions activity-related forecasts than EGAS 4.0. Categories for which additional data are available include:

- Agricultural production;
- Construction activity;
- Automotive production;
- Coatings demand;
- Solvents demand;
- Housing activity; and
- Steel production.

Two economic forecasting firms provide the majority of emissions activity forecast data: RFA and WEFA. It is important to note, however, that F.W. Dodge provides the most detailed construction activity forecasts and Freedonia develops detailed coatings and solvents forecasts. Information on the forecast data available from RFA, WEFA, and F.W. Dodge is presented in Sections III.D. through III.F. Background information on Freedonia forecast data is provided in Section III.G.1. For source categories where more specific emissions activity data are available, it would be possible to supplement the REMI-based growth factors with the activity data from these sources. It should be noted, however, that this would reduce the comparability of the forecast data within the physical output module of EGAS in that different macroeconomic assumptions could underlie the different forecasts. If the comparability of forecast data is deemed a significant concern, another option would be to replace the entire set of REMI economic sector forecasts with forecast data from either RFA or WEFA, each of which have a significant number of physical output-related variables. Implementing this approach would, however, require a substantial level of effort since EGAS has been developed to work with REMI's files.

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APPENDIX A
SUPPLEMENTAL EMISSION GROWTH SURROGATE INFORMATION

Tables

Table A-1. Industry Coverage of DRI Output and Employment Forecasts

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
Agricultural, Forestry, & Fishery Products			
1. Livestock	Pt. 019, 0211-4, Pt. 0219, 024, 0251-3, Pt. 0259, 0271-3, Pt. 0279, Pt. 029	NA	NA
2. Cotton	0131, Pt. 019, Pt. 0219, Pt. 0259, Pt. 029	NA	NA
3. Food Grains & Feed Grains	0111-5, Pt. 0139, Pt. 019, Pt. 0219, Pt. 0259, Pt. 029	NA	NA
4. Tobacco	0132, Pt. 019, Pt. 0219, Pt. 0259, Pt. 029	NA	NA
5. Other Crops	0116-9, 016-8, Pt. 019, Pt. 0219, Pt. 0259, Pt. 029	NA	NA
6. Forestry Products	081, 083, 097	available	same
7. Commercial Fishing	091	available	same
8. Agricultural, Forestry, & Fishery Services	Pt. 02, 071-8, 085, 092	available	0254, 071-8, 085, 092
Mining			
9. Iron & Ferroalloy Ores	101,106	available	same
10. Copper Ore Mining	102	available	same
11. Miscellaneous Nonferrous Ores	103-4, Pt. 108, 109	available	103-4, 108-9
12. Coal Mining	122-3, Pt. 124	available	122-124
13. Crude Petroleum	Pt. 131, Pt. 138	available	1311, 1321, 1381-2, 1389
*(Crude Petroleum & Natural Gas combined on Regional Level)			
14. Natural Gas	Pt 131, 132, Pt. 138	NA	NA
15. Stone & Clay Mining & Quarrying	141-5, Pt. 148, 149	available	141-5, 148-9
16. Chemical & Fertilizer Mining	147	available	same
Construction			
17. New Construction	Pt. 15-17, Pt. 108, Pt. 124, Pt. 138, Pt. 148	available	15-17
18. Maintenance & Repair Construction	Pt. 15-17, Pt. 138	NA	NA
Ordnance & Accessories			
19. Complete Guided Missiles	3761	available	same
20. Ammunition, Except for Small Arms	3483	available	same
21. Tanks & Tank Components	3795	available	same
22. Small Arms & Ammunition	3482, 3484	available	same
23. Other Ordnance & Accessories	3489	available	same
Food & Kindred Products			
24. Meat Processing	2011, 2013	available	same
25. Poultry Processing	2015	available	same
26. Dairy Products	202	available	same
27. Fresh, Frozen, & Canned Seafood	2091-2	available	same
28. Canned & Frozen Food, Except Fish	203	available	same
29. Grain Mill Products	204	available	same
30. Bakery Products	205	available	same
31. Sugar & Confectionery Products	206	available	same
32. Alcoholic Beverages	2082-5	available	same
33. Non-Alcoholic Beverages	2086-7	available	same
34. Fats & Oils	207	available	same
35. Miscellaneous Food Products	209 excl. 2091-2	available	same

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
Tobacco Products			
36. Tobacco Products	21	available	same
Textiles & Apparel			
37. Fabric Mills	221-6 excl. 225, 2269	available	same
38. Yarn & Thread Mills	2269, 228	available	same
39. Floor Coverings	227	available	same
40. Miscellaneous Textile Products	229	available	same
41. Hosiery & Knitting Mills	225	available	same
42. Apparel from Purchased Materials	231-8	available	same
43. Miscellaneous Fabricated Textile Products	239	available	same
Lumber & Wood Products			
44. Logging Camps & Contractors	241	available	same
45. Sawmills	242	available	same
46. Veneer & Plywood	2435-6	available	same
47. Reconstituted Wood Products	2493	available	same
48. Millwork & Wood Products	243-9 excl. 2435-6, 2451-2, 2493	available	same
49. Mobile Homes	2451	available	same
50. Prefabricated Wood Buildings & Components	2452	available	same
Furniture & Fixtures			
51. Household Furniture	251	available	same
52. Office Furniture	252-253	available	same
53. Partitions, Fixtures, & Miscellaneous Furniture	254, 259	available	same
Paper & Allied Products			
54. Pulp Mills	261	available	same
55. Paper & Paperboard Mills	262, 263	available	same
56. Paper Coating & Laminating	2671-2, 2675	available	same
57. Sanitary Paper Products	2676	available	same
58. Stationery & Envelopes	2677-8	available	same
59. Other Converted Paper & Board	2673-4, 2679	available	same
60. Paperboard Containers & Boxes	265	available	same
Printing & Publishing			
61. Newspapers	271	available	same
62. Periodicals	272	available	same
63. Book Publishing & Printing	273-4	available	same
64. Commercial Printing	275	available	same
65. Miscellaneous Printing & Publishing	276-9	available	same
Chemicals & Products			
66. Industrial Inorganic & Organic Chemicals	281, 286	available	same
67. Fertilizers	2873-5	available	same
68. Pesticides & Agricultural Chemicals, N.E.C.	2879	available	same
69. Adhesives & Sealants	2891	available	same
70. Printing Ink	2893	available	same
71. Other Chemical Products	2892, 2895, 2899	available	same
Plastic & Synthetic Materials			
72. Plastic Materials & Resins	2821	available	same
73. Synthetic Rubber	2822	available	same
74. Synthetic Fibers	2823-4	available	same

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
Drugs, Cleaning, & Toilet Preparations			
75. Drugs	283	available	same
76. Soap & Cleaning Preparations	284 excl. 2844	available	same
77. Toilet Preparations	2844	available	same
Paints & Allied Products			
78. Paints & Allied Prod	285	available	same
Petroleum Refining & Related Products			
79. Petroleum Refining, Except Fuel Oil * (Petroleum Refining & Fuel Oil Combined on Regional Level)	2911 excl. 29114-5, 29117	available	2911
80. Fuel Oil	29114-5	NA	NA
81. Lubricating Oils & Greases	2992, 29117	available	2992
82. Asphalt Paving & Roofing Products; Petroleum & Coal Products, N.E.C.	295, 2999	available	same
Rubber & Miscellaneous Plastic Products			
83. Tires & Inner Tubes	301	available	same
84. Rubber & Plastics Footwear	302	available	same
85. Hose & Belting; Gaskets, Packing & Sealing Devices; Fabricated Rubber Products, N.E.C.	305-6	available	same
86. Miscellaneous Plastics Products	308	available	same
Leather & Leather Products			
87. Leather Tanning & Finishing	3111	available	same
88. Leather Footwear	313-4	available	same
89. Other Leather Goods	315-9	available	same
Stone, Clay, & Glass Products			
90. Glass & Products, Except Containers	321, 3229, 323	available	same
91. Glass Containers	3221	available	same
92. Hydraulic Cement	324	available	same
93. Structural Clay Products	325	available	same
94. Kitchen Pottery Products	3262, 3263, 3269	available	same
95. Porcelain Plumbing & Electrical Supplies	3261, 3264	available	same
96. Concrete & Gypsum	3271-3, 3275	available	same
97. Lime & Cut Stone	3274, 328	available	same
98. Mineral Wool Insulation Products	3296	available	same
99. Abrasives & Other Mineral Products	329 excl. 3296	available	same
Primary Ferrous Metals			
100. Blast Furnace & Basic Steel Products	331	available	same
101. Iron & Steel Foundries	332	available	same
102. Iron & Steel Forgings	3462	available	same
103. Primary Metal Products, N.E.C.	339	available	same
Primary Nonferrous Metals			
104. Copper	3331, Pt. 3341, 3351	available	3331, 3351
105. Aluminum	3334, Pt. 3341, 3353-5, 3363, 3365	available available	3334, 3353-5, 3363, 3365
106. Nonferrous Metals, N.E.C.	3339, Pt. 3341	available	3339, 3341
107. Nonferrous Rolling & Drawing, N.E.C.	3356	available	same
108. Nonferrous Wire & Cable	3357	available	same
109. Nonferrous Castings & Forgings, N.E.C.	3364, 3366, 3369, 3463	available	same

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
Fabricated Metal Products			
110. Metal Cans	3411	available	same
111. Metal Barrels, Drums & Pails	3412	available	same
112. Plumbing & Heating Equipment	3431-3	available	same
113. Structural Metal & Plate Work	3441, 3443	available	same
114. Structural Metal Products, N.E.C.	3442, 3444-9	available	same
115. Screw Machinery Products & Fasteners	345	available	same
116. Automotive Stampings	3465	available	same
117. Metal Stampings, Except Auto	346 excl. 3465	available	same
118. Cutlery, Hand Tools, & Hardware, N.E.C.	342	available	same
119. Metal Coating & Engraving	347	available	same
120. Pipe, Valves, & Pipe Fittings	3491, 3492, 3494, 3498	available	same
121. Miscellaneous Fabricated Metal Products	3493, 3495-7, 3499	available	same
Engines & Turbines			
122. Turbines & Turbine Generating Sets	3511	available	same
123. Internal Combustion Engines, N.E.C.	3519	available	same
Farm, Construction, & Mining Machinery			
124. Farm Machinery & Equipment	3523	available	same
125. Lawn & Garden Equipment	3524	available	same
126. Construction Machinery	3531	available	same
127. Mining & Oil Field Machinery	3532-3	available	same
Materials Handling Machinery & Equipment			
128. Elevators & Materials Handling Equipment	3534-6	available	same
129. Industrial Trucks & Tractors	3537	available	same
Metalworking Machinery & Equipment			
130. Machine Tools, Metal Cutting	3541	available	same
131. Machine Tools, Metal Forming	3542	available	same
132. Welding Apparatus	3548	available	same
133. Other Metalworking Tools & Machinery	3543-9 excl. 3548	available	same
Special Industry Machinery & Equipment			
134. Food Products Machinery	3556	available	same
135. Textile Machinery	3552	available	same
136. Woodworking Machinery	3553	available	same
137. Paper Industries Machinery	3554	available	same
138. Printing Trades Machinery	3555	available	same
139. Special Industry Machinery, N.E.C.	3559	available	same
General Industrial Machinery & Equipment			
140. Pumps & Compressors	3561, 3563	available	same
141. Ball & Roller Bearings	3562	available	same
142. Blowers & Fans	3564	available	same
143. Packaging Machinery	3565	available	same
144. Miscellaneous General Industrial Machinery	3566-9	available	same
Other Industrial & Commercial Machinery			
145. Fluid Power Equipment	3593-4	available	same
146. Miscellaneous Industrial & Commercial Machinery	3592, 3596, 3599	available	same
147. Refrigeration & Heating Equipment	3585	available	same

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
148. Other Service Industry Machinery	358 excl. 3585	available	same
Computer & Office Machinery			
149. Electronic Computers	3571	available	same
150. Computer Peripheral Equipment	3572, 3575, 3577	available	same
151. Calculating & Other Office Machinery	3578-9	available	same
Electrical Industrial Equipment & Apparatus			
152. Transformers	3612	available	same
153. Switchgear & Switchboard Equipment	3613	available	same
154. Motors & Generators	3621	available	same
155. Relays & Industrial Controls	3625	available	same
156. Miscellaneous Electrical Industrial Apparatus	3624, 3629	available	same
Household Appliances			
157. Major Household Appliances	3631-3	available	same
158. Small Household Appliances	3634-9	available	same
Electric Lighting & Wiring Equipment			
159. Electric Lamp Bulbs & Tubes	3641	available	same
160. Electrical Wiring Devices	3643-4	available	same
161. Electrical Lighting Fixtures	3645-8	available	same
Audio, Video, & Communication Equipment			
162. Household Audio & Video Equipment	3651	available	same
163. Records, Tapes, CDs (Audio)	3652	available	same
164. Telephone & Telegraph Equipment	3661	available	same
165. Radio & TV Broadcasting Equipment & Communications Equipment, N.E.C.	3663, 3669	available	same
Electronic Components & Accessories			
166. Electron Tubes	3671	available	same
167. Semiconductors	3674	available	same
168. Miscellaneous Electronic Components	3672, 3675-9	available	same
Other Electrical Machinery & Supplies			
169. Storage Batteries	3691	available	same
170. Primary Batteries	3692	available	same
171. Engine Electrical Equipment	3694	available	same
172. Magnetic & Optical Recording Media	3695	available	same
173. Electrical Equipment & Supplies, N.E.C.	3699	available	same
Motor Vehicles & Equipment			
174. Truck & Bus Bodies	3713	available	same
175. Truck Trailers	3715	available	same
176. Motor Vehicles	3711	available	same
177. Motor Vehicle Parts & Accessories	3714	available	same
Aircraft & Parts			
178. Aircraft	3721	available	same
179. Aircraft & Missile Engines & Parts	3724, 3764	available	same
180. Aircraft & Missile Parts & Equipment, N.E.C.	3728, 3769	available	same

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
Other Transportation Equipment			
181. Shipbuilding & Repairing	3731	available	same
182. Boatbuilding & Repairing	3732	available	same
183. Railroad Equipment	374	available	same
184. Motor Homes & Recreational Vehicles	3716, 3792, 3799	available	same
185. Motorcycles, Bicycles, & Parts	375	available	same
Scientific & Controlling Instruments			
186. Search, Detection, & Navigation Equipment	3812	available	same
187. Measuring & Controlling Instruments	382 excl. 3825-7	available	same
188. Electricity Measuring Instruments	3825	available	same
189. Laboratory & Optical Instruments	3826-7	available	same
190. Medical Instruments & Supplies	3841-3	available	same
191. Electromedical & X-Ray Equipment	3844-5	available	same
192. Watches & Clocks	387	available	same
Ophthalmic & Photographic Equipment			
193. Ophthalmic Goods	385	available	same
194. Photographic Equipment & Supplies	386	available	same
Miscellaneous Manufacturing			
195. Jewelry & Silverware	391	available	same
196. Musical Instruments & Parts	393	available	same
197. Toys & Sporting Goods	394	available	same
198. Office & Artists' Materials	395	available	same
199. Miscellaneous Durables & Semidurables	396, 399	available	same
Transportation & Warehousing			
200. Railroads & Rail-Related Services	40, 474	available	same
201. Passenger Transportation, N.E.C.	41	available	same
202. Trucking and Courier Services, Except Air	421, 423	available	same
203. Warehousing and Storage	422	available	same
204. Water Transportation	44	available	same
205. Air Transportation	45	available	same
206. Pipelines, Except Natural Gas	46	available	same
207. Transportation Services, N.E.C.	472, 473, 478	available	same
Communications & Utilities			
208. Telephone and Telegraph Communications, and Communications Services N.E.C.	481-2, 489	available	same
209. Cable and Other Pay Television Services	484	available	same
210. Radio & TV Broadcasting	483	available	same
211. Electric Utilities	491, 4931	available	same
212. Gas Utilities	492, 4932, 4939	available	same
213. Water & Sewer Services	494-7	available	same
Wholesale & Retail Trade			
214. Wholesale Trade	50, 51	available	same
215. Retail Trade	52-57, 59	available	same
Finance, Insurance, & Real Estate			
216. Banking	60	available	same
217. Non-Bank Credit Institutions	61, 67 excl. 6732	available	same
218. Security & Commodity Brokers	62	available	same
219. Insurance Carriers & Agents	63-64	available	same

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
220. Owner-Occupied Dwellings	NA	NA	NA
221. Real Estate	65, excl. 6552	available	same
Personal Services, Except Automotive			
222. Hotels & Other Lodging Places	70	available	same
223. Personal & Repair Services, Except Auto	72, 762-764	available	same
Business & Professional Services, Except Medical			
224. Advertising	731	available	same
225. Equipment Rental & Leasing	735	available	same
226. Personnel Supply Services	736	available	same
227. Computer Processing & Software	737	available	same
228. Other Business Services, N.E.C.	769, 732-4, 738	available	same
229. Legal Services	81	available	same
230. Engineering, Architectural, & Surveying Services	871	available	same
231. Management & Consulting Services	874	available	same
232. Testing & Research Labs	873 excl. 8733	available	same
233. Accounting, Auditing, & Miscellaneous Professional Services	872, 89	available	same
Eating & Drinking Places			
234. Eating & Drinking Places	58	available	same
Automobile Repair & Services			
235. Auto Rental & Leasing	751	available	same
236. Auto Repair, Parking, & Other Services	752, 753, 754	available	same
Amusements			
237. Motion Pictures & Video Rental	78	available	same
238. Amusement & Recreation Services	79	available	same
Health Services			
239. Doctors & Dentists	801-803, 8041	available	same
240. Hospitals	806	available	same
241. Nursing & Personal Care Facilities	805	available	same
242. Home Health Care Services	808	available	same
243. Other Medical Services	074, 8042-3, 8049, 807, 809	available	same
Miscellaneous Services			
244. Educational Services	82	available	same
245. Nonprofit Organizations	84, 86, 8733, 6732	available	same
246. Social Services, N.E.C.	83	available	same
Government Enterprises			
247. US Postal Service	4311	NA	NA
248. Federal Government Enterprises, Except Postal Service & Utilities		available	same
249. State & Local Government Enterprises, Except Utilities, Upper Education, & Medical Services		available	same
250. State & Local Government, Hospitals and Other Medical Services		NA	NA
251. State & Local Government, Upper Education		NA	NA
Other Industries			

Table A-1 (continued)

INDUSTRY SECTOR	1987 SIC CODES FOR INDUSTRY DEFINITIONS	REGIONAL AVAILABILITY	1987 SIC CODES FOR REGIONAL DEFINITIONS
252. Noncomparable Imports		NA	NA
253. Scrap, Used, & Secondhand Goods		NA	NA
254. Dummy Sector		NA	NA

Table A-2. WEFA Crop Forecasts

	State				*County*			
Crop	**Area Planted**	**Area Harvested**	**Yield**	**Prodn.**	**Area Planted**	**Area Harvested**	**Yield**	**Prodn.**
Field & Row Crops								
Alfalfa Seed		X	X	X				
Alfalfa Hay		X	X	X		X		
Barley	X	X	X	X	X			
Corn	X	X	X	X	X			
Cotton	X	X	X	X	X			
Dry Beans	X				X			
Dry Peas	X							
Lentils	X							
Canola	X							
Mint		X						
Flax	X				X			
Hops		X	X	X				
Oats	X				X			
Peanuts	X	X				X		
Potatoes	X				X			
Rice	X	X	X	X	X			
Rye	X				X			
Sorghum	X	X	X	X	X			
Soybeans	X	X	X	X	X			
Sugarbeets	X				X			
Sugarcane		X						
Sunflowers	X				X			
Sweet Potatoes	X							
Tobacco		X				X		
Taro		X						
Wheat, Durum	X	X	X	X	X			
Wheat, Other Spring	X	X	X	X	X			
Wheat, Winter	X	X	X	X	X			
Fruits and Nuts								
Almonds	X				X			
Apples	X				X			
Apricots	X							
Bananas	X							
Cherries	X				X			
Coffee	X							
Cranberries	X				X			
Dates	X							
Figs	X							
Filberts	X							
Grapes	X				X			
Guavas	X							
Kiwi	X							
Macadamia Nuts	X							
Nectarines	X				X			
Olives	X							
Papayas	X							
Peaches	X				X			
Pears	X				X			
Pineapple	X							
Pistachios	X							
Plums/Prunes	X				X			
Grapefruit	X				X			
Lemons	X				X			

Table A-2 (continued)

Crop	*State*				*County*			
	Area Planted	Area Harvested	Yield	Prodn.	Area Planted	Area Harvested	Yield	Prodn.
Limes	X							
Oranges	X				X			
Tangelos	X				X			
Tangerines	X							
Temples	X							
Walnuts	X				X			
Bushberries	X							
Pecans	X							
Persimmons	X							
Pomegranates	X							
Vegetables								
Asparagus	X				X			
Broccoli	X				X			
Carrots	X				X			
Cauliflower	X				X			
Celery	X				X			
Cucumbers	X				X			
Green Peas	X				X			
Honeydew	X				X			
Lettuce	X				X			
Onions	X							
Snapbeans		X				X		
Strawberries	X							
Sweet Corn	X				X			
Tomatoes	X				X			
Artichokes		X				X		
Beets		X				X		
Brussel Sprouts		X				X		
Cabbage		X				X		
Cantaloupes		X				X		
Eggplant		X						
Garlic		X				X		
Ginger		X						
Green Peppers		X						
Lima Beans		X						
Parsley		X				X		
Pumpkins		X				X		
Radishes		X				X		
Spinach		X				X		
Watermelons		X				X		

Table A-3. Market Research Studies Applicable to Emission Source Categories

Date	Source	Title
		AUTOMOTIVE AND TRANSPORT
01/00	Packaged Facts	MARKET FOR AUTOMOTIVE AFTERMARKET PRODUCTS
08/99	Freedonia Group	AUTOMOTIVE FLUIDS & CHEMICALS TO 2003
06/99	Freedonia Group	AUTOMOTIVE LUBRICANTS TO 2003
04/99	Freedonia Group	RECREATIONAL VEHICLES TO 2003
02/99	Freedonia Group	WORLD AUTOMOTIVE AFTERMARKET TO 2002
04/96	Freedonia Group	RECREATIONAL BOATING TO 2000
04/95	Freedonia Group	WORLD COMMERCIAL AEROSPACE TO 1998
		CHEMICALS
04/00	Freedonia Group	INDUSTRIAL & INSTITUTIONAL CLEANING CHEMICALS
04/00	Freedonia Group	BIOCIDES
03/00	Freedonia Group	WORLD AGRICULTURAL BIOTECHNOLOGY: GMOS
03/00	Freedonia Group	OILFIELD CHEMICALS
03/00	Freedonia Group	INDUSTRIAL WATER MANAGEMENT CHEMICALS
02/00	Freedonia Group	DEFOAMERS TO 2004
02/00	Freedonia Group	BROMINE TO 2003
01/00	SRI Consulting	CHEMICAL ECONOMICS HANDBOOK
01/00	SRI Consulting	WORLD PETROCHEMICALS PROGRAM
01/00	Freedonia Group	METAL FINISHING CHEMICALS TO 2003
12/99	Freedonia Group	PULP & PAPER CHEMICALS TO 2003
12/99	Freedonia Group	CEMENT & CONCRETE ADDITIVES TO 2003
12/99	Freedonia Group	ACRYLIC RESINS TO 2003
11/99	Freedonia Group	SPECIALTY GASES TO 2003
11/99	Freedonia Group	POLYETHYLENE TEREPHTHALATE (PET) RESINS TO 2003
11/99	Freedonia Group	CATALYSTS: CHEMICAL & PETROLEUM TO 2003
09/99	Freedonia Group	ACRYLIC ACID & DERIVATIVES TO 2003
08/99	Freedonia Group	ELECTRONIC CHEMICALS TO 2003
07/99	Freedonia Group	SORBENTS TO 2003
07/99	Freedonia Group	DISINFECTANT & ANTIMICROBIAL CHEMICALS TO 2003
07/99	Freedonia Group	COSMECEUTICALS TO 2003
05/99	Freedonia Group	SOLVENTS TO 2003
05/99	Freedonia Group	COSMETIC & TOILETRY CHEMICALS TO 2003
05/99	Freedonia Group	AMINO ACIDS TO 2003
03/99	BCC	PULP AND PAPER CHEMICALS
03/99	Freedonia Group	INDUSTRIAL LUBRICANTS TO 2003
03/99	Freedonia Group	INDUSTRIAL GASES TO 2003
02/99	Freedonia Group	PLANT-DERIVED CHEMICALS TO 2003
12/98	Freedonia Group	PRINTING INKS TO 2002
11/98	Freedonia Group	AMINES TO 2002
10/98	Freedonia Group	PHARMACEUTICAL CHEMICALS TO 2002
09/98	BCC	SURFACTANT ADDITIVES & FORMULATED CLEANING PRODUCTS
09/98	Freedonia Group	PHOTOGRAPHIC CHEMICALS & MATERIALS TO 2002
09/98	Freedonia Group	GASOLINE & OTHER FUEL ADDITIVES TO 2002
08/98	Freedonia Group	TEXTILE PROCESSING & FINISHING CHEMICALS TO 2002
08/98	Freedonia Group	SURFACTANTS TO 2002
06/98	Freedonia Group	LUBRICANT ADDITIVES TO 2002
06/98	Freedonia Group	EXPLOSIVES & PYROTECHNICS TO 2002
06/98	Freedonia Group	PHENOLIC RESINS IN NORTH AMERICA TO 2002
04/98	Freedonia Group	OILFIELD CHEMICALS TO 2002

Table A-3 (continued)

Date	Source	Title
		CHEMICALS (continued)
04/98	Freedonia Group	I&I CLEANING CHEMICALS TO 2002
03/98	Freedonia Group	WORLD CARBON BLACK TO 2001
02/98	BCC	ADDITIVES FOR PAINTS
11/97	BCC	CHEMICALS FOR COSMETICS & TOILETRIES
09/97	Freedonia Group	FLUOROCHEMICALS TO 2001
06/97	Freedonia Group	WATER MANAGEMENT CHEMS: INDUSTRIAL TO 2001
09/96	Freedonia Group	ACETIC ACID & DERIVATIVES TO 2000
08/96	Freedonia Group	PAINT & COATING CHEMICALS TO 2000
06/95	BCC	ALTERNATIVE TECHNOLOGIES TO REGULATED CLEANING SOLVENTS: A GROWING INDUSTRY
12/94	BCC	SOLVENTS AND CONCOMITANT ANCILLARY SOLVENT SUBSTITUTE AND RECYCLING
10/94	BCC	VOLATILE ORGANIC COMPOUNDS TECHNOLOGY: MARKETS & APPLICATIONS
		COATINGS AND ADHESIVES
03/00	Freedonia Group	EPOXY RESINS IN NORTH AMERICA
04/99	Freedonia Group	ADHESIVES TO 2003
11/98	Freedonia Group	PAINTS & COATINGS TO 2002
11/98	Freedonia Group	LABELS TO 2002
11/98	Kalorama (SBI)	PRESSURE-SENSITIVE PRODUCTS MARKET (1998)
10/98	Freedonia Group	PRESSURE-SENSITIVE TAPES TO 2002
06/98	Freedonia Group	SEALANTS & CAULKS TO 2002
03/98	Frost and Sullivan	U.S. PAINT AND COATING MARKETS
03/98	Kalorama (SBI)	PRODUCT PAINTS, FINISHES, AND COATINGS MARKET TRENDS, THE U.S. MARKET -- 1998
02/98	Frost and Sullivan	NORTH AMERICAN AUTOMOTIVE COATING AND ADHESIVE TECHNOLOGIES
02/98	Kalorama (SBI)	ARCHITECTURAL PAINTS AND COATINGS
01/98	Kalorama (SBI)	ADHESIVES AND SEALANTS
07/95	BCC	ENVIRONMENTALLY ACCEPTABLE COATINGS: THE INDUSTRY
		CONSTRUCTION and BUILDING
02/00	Freedonia Group	ASPHALT PRODUCTS & MARKETS TO 2003
10/99	Freedonia Group	WORLD HEAVY CONSTRUCTION EQUIPMENT TO 2003
09/99	Freedonia Group	WOOD & COMPETITIVE MATERIALS IN RESIDENTIAL BUILDINGS TO 2003
07/99	Freedonia Group	FLAT GLASS TO 2003
05/99	Freedonia Group	GLASS FIBERS TO 2003
04/99	Freedonia Group	ROOFING TO 2003
03/99	Freedonia Group	CONSTRUCTION CHEMICALS TO 2003
03/98	Freedonia Group	CEMENT & CONCRETE ADMIXTURES TO 2002
02/98	Freedonia Group	ASPHALT TO 2001
08/97	BCC	ENVIRONMENTALLY ACCEPTABLE SOLDERING AND CLEANING
		CONSUMER and HOUSEHOLD GOODS
09/99	Kalorama (Packaged Facts)	HOUSEHOLD CLEANING PRODUCTS MARKET
07/99	Kalorama (SBI)	U.S. FLOOR COVERINGS INDUSTRY
02/99	Kalorama (Packaged Facts)	LAWN AND GARDEN MARKET, U.S.--1999
01/99	Freedonia Group	CARPETS & RUGS TO 2002
11/98	Freedonia Group	POWER LAWN & GARDEN EQUIPMENT TO 2002

Table A-3 (continued)

Date	Source	Title
		CONSUMER and HOUSEHOLD GOODS (continued)
06/97	Kalorama (Packaged Facts)	HOME OFFICE FURNITURE MARKET--1997
07/95	Kalorama	PERSONAL LEATHER PRODUCTS
03/95	Freedonia Group	MUNICIPAL SOLID WASTE TO 2000
		ENERGY and ENVIRONMENT
12/99	Freedonia Group	BATTERIES TO 2003
07/99	BCC	SMALL-SCALE POWER GENERATION: HOW MUCH? WHAT KIND?
05/99	BCC	BATTERY AND ELECTRIC VEHICLE INDUSTRY REVIEW
04/95	Freedonia Group	HAZARDOUS WASTE TO 2000
		INDUSTRIAL AND OFFICE COMPONENTS, EQUIPMENT, AND SUPPLIES
11/99	Freedonia Group	PUMPS TO 2003
10/99	Freedonia Group	WORLD VALVES TO 2003
09/99	Freedonia Group	REFRACTORIES TO 2003
08/99	Freedonia Group	DIESEL ENGINES & PARTS TO 2003
06/99	Freedonia Group	PLASTIC PROCESSING MACHINERY TO 2003
04/99	Freedonia Group	FRACTIONAL HORSEPOWER MOTORS TO 2003
04/99	BCC	THE CHANGING REFRACTORY INDUSTRY: NEW TECHNOLOGIES
03/99	Freedonia Group	INDUSTRIAL VALVES TO 2003
11/98	Freedonia Group	INSULATED WIRE & CABLE - PRIVATE COMPANIES REPORT
11/98	Freedonia Group	GEARS TO 2002
08/98	Kalorama	FOODSERVICE EQUIPMENT (1998)
07/98	Kalorama	TEXTILE MACHINERY (1998)
06/98	Kalorama	FOOD PROCESSING AND PACKAGING EQUIPMENT
06/98	Freedonia Group	INDUSTRIAL CONTROLS TO 2002
05/98	Freedonia Group	MATERIAL HANDLING EQUIPMENT & SYSTEMS TO 2002
05/98	Kalorama	PLUMBING FIXTURES AND FITTINGS (1998)
02/98	BCC	THE NEW GENERATION OF ANALYTICAL INSTRUMENTS
12/97	Kalorama	AIR CONDITIONING EQUIPMENT (1997)
11/97	Kalorama	COMMERCIAL REFRIGERATION EQUIPMENT (1997)
02/97	Freedonia Group	COMMERCIAL REFRIGERATION EQUIPMENT TO 2001
01/97	Kalorama (SBI)	INDUSTRIAL PUMPS
01/97	Kalorama	FLUID POWER PUMPS AND MOTORS
01/97	Kalorama	COMPRESSORS, VACUUM PUMPS, AND SPRAYING EQUIPMENT
12/96	BCC	THE STATE OF MAJOR U.S. ANALYTICAL INSTRUMENTS
10/96	Kalorama	OFFICE FURNITURE
07/96	Kalorama	FABRICATED WIRE PRODUCTS
01/96	Freedonia Group	POWDER METALS, CASTINGS & FORGINGS TO 2000
11/95	Kalorama	CONVEYORS AND CONVEYING EQUIPMENT MARKET
04/94	Kalorama	PRESSURE VESSELS AND TANKS
		MATERIALS
10/98	BCC	HIGH PERFORMANCE CERAMIC COATINGS: TECHNOLOGIES AND MARKETS
04/98	BCC	HIGH TECH CERAMICS INDUSTRY REVIEW
02/98	BCC	THE SUPERCONDUCTOR INDUSTRY - A TECHNICAL ECONOMIC AND MARKET ANALYSIS
12/97	BCC	SEMICONDUCTOR BUILDING BLOCK MATERIALS: GROWING MARKETS FOR MATERIAL PRECURSORS
12/97	BCC	IRON AND IRON OXIDE POWDERS: TRENDS AND MARKETS
11/97	BCC	ELECTRONICS MATERIALS INDUSTRY REVIEW
07/97	BCC	OPTICAL MATERIAL AND ENGINEERING INDUSTRY REVIEW

Table A-3 (continued)

Date	Source	Title
		MATERIALS (continued)
04/97	BCC	ADVANCED STRUCTURAL FIBERS FROM PRECURSORS: CARBON, SILICON CARBIDE
01/97	BCC	NEW ABRASIVES AND ABRASIVES PRODUCTS, TECHNOLOGIES, MARKETS
02/95	BCC	HOSE AND TUBING MARKETS
		METALS AND MINERALS
07/99	Freedonia Group	BEVERAGE CONTAINERS TO 2003
05/98	Freedonia Group	METAL CANS TO 2002
08/97	Freedonia Group	GYPSUM PRODUCTS IN NORTH AMERICA TO 2001
12/96	Freedonia Group	ALUMINUM COMPOUNDS TO 2000
10/95	BCC	THE FUTURE OF THE STEEL INDUSTRY
10/95	Freedonia Group	ABRASIVES PRODUCTS & MARKETS TO 2000
		PAPERS AND TEXTILES
12/99	Freedonia Group	PULP & PAPER TO 2003
08/99	Freedonia Group	COATED FABRICS TO 2003
01/99	Freedonia Group	CORRUGATED & PAPERBOARD BOXES TO 2002
		PLASTICS AND POLYMERS
12/99	Freedonia Group	WORLD PLASTIC PIPE TO 2003
07/99	Freedonia Group	LARGE DIAMETER PIPE TO 2003
06/99	Freedonia Group	FOAMED PLASTICS TO 2003
04/99	Freedonia Group	REINFORCED PLASTICS TO 2003
03/99	Freedonia Group	PLASTIC & COMPETITIVE PIPE TO 2003
02/99	BCC	POLYMERIC MATERIALS & FLAME RETARDANTS FOR WIRE & CABLE
12/98	Freedonia Group	POLYVINYL CHLORIDE TO 2002
09/98	Freedonia Group	EMULSION POLYMERS TO 2002
07/98	Freedonia Group	PLASTIC FILM TO 2002
06/98	Freedonia Group	POLYETHYLENE TO 2002
01/98	Freedonia Group	POLYPROPYLENE TO 2001
10/97	Freedonia Group	ENGINEERED PLASTICS TO 2001
09/97	Freedonia Group	PLASTICS IN CONSTRUCTION TO 2001
07/97	BCC	THE COMPETITIVE PIPE INDUSTRY
12/96	Freedonia Group	POLYVINYL CHLORIDE IN NORTH AMERICA TO 2005
		PRINTING AND PUBLISHING
02/98	Kalorama (SBI)	PRINTING INK
		RUBBER AND ELASTOMERS
01/00	Freedonia Group	PLASTIC ELASTOMERS TO 2003
10/98	Freedonia Group	INDUSTRIAL RUBBER PRODUCTS TO 2002
04/97	Freedonia Group	THERMOPLASTIC ELASTOMERS TO 2001